PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY

HELD AT PHILADELPHIA

FOR PROMOTING USEFUL KNOWLEDGE

VOL. LII NOVEMBER–DECEMBER, 1913 NO. 212

THE MARINE TERTIARY STRATIGRAPHY OF THE NORTH PACIFIC COAST OF AMERICA.

BY RALPH ARNOLD AND HAROLD HANNIBAL.

(PLATES XXXVII–XLVIII.)

COLUMNAR SECTION OF THE COLUMBIA RIVER AND SHOALWATER BAY DISTRICT.

Pleistocene marine terraces, 50′

Pliocene basalt

Monterey formation, 400′

Astoria Series

Seattle formation
tuffaceous shales and sandstone with interbedded basalts of Nazel, Grays River, Ilwaco, and Astoria.
5,000′

San Lorenzo formation
tuffaceous sandstones and shales with interbedded basalts of Winlock, Pe Ell, Holcomb, Clatskanie, and Scapoose.
10,000′

Tejon Series

Olequa formation
tuffaceous lignitic sandstones of Little Falls and Coal Creek above Stella.
3,000′

Chehalis formation
tuffaceous lignitic sandstones and shales of marine and estuarine origin east of Winlock and in the upper Cowlitz Basin.
10,000′

Bedrock complex

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COLUMNAR SECTION OF WILLAMETTE VALLEY AND UPPER UMPQUA BASIN.

Pliocene basalt	
Astoria Series	*San Lorenzo* tuffs of Silverton and Eugene. 1,000′
Tejon Series	*Arago formation* tuffaceous and arkose sandstone of Umpqua Basin, coarse basic tuffs farther north on Santiam River. 10,000′
Bedrock complex	

COLUMNAR SECTION OF THE COAST RANGE AND COAST OF OREGON.

Marine Pleistocene terraces, 50′	
Elk River formation, 300′	
Merced formation, 50′	
Empire formation, 500′	
Monterey formation sandstone and clay shale of Newport. 2,000′	
Astoria Series	*Seattle formation* tuffaceous sandstone and shale of Nehalem and Yaquina Bays. 5,000′
	San Lorenzo formation tuffaceous sandstone and shale of Upper Nehalem and Yaquina Rivers. 5,000′
Tejon Series	*Arago formation* tuffaceous lignitic sandstones and shales of Coos Bay district becoming more and more tuffaceous to north and grading into coarse tuffs and basaltic flows of Wilson River and South Nehalem River. 10,000′
Bedrock complex	

COLUMNAR SECTION OF THE GRAYS HARBOR AND CHEHALIS VALLEY DISTRICT.

	Admiralty till
	Empire formation sandstones and tuffaceous shales with basalt tuffs at base, west and north of Chehalis Valley. 4,000′
	Monterey formation sandstones and clay shales south of Chehalis Valley. 4,000′
Astoria Series	*Seattle formation* tuffaceous s.s. and sh. of Delazine Cr. 1,600′
	San Lorenzo formation tuffaceous sandstone and shale at Lincoln Creek and north of Oakville, Porter, and Elma with basalts at base. 3,000′
Tejon Series	*Chehalis formation* tuffaceous lignitic sandstones and shales, marine and estuarine with interbedded basic flows and tuffs at Chehalis and the Balch syncline. 9,000′
	Bedrock complex

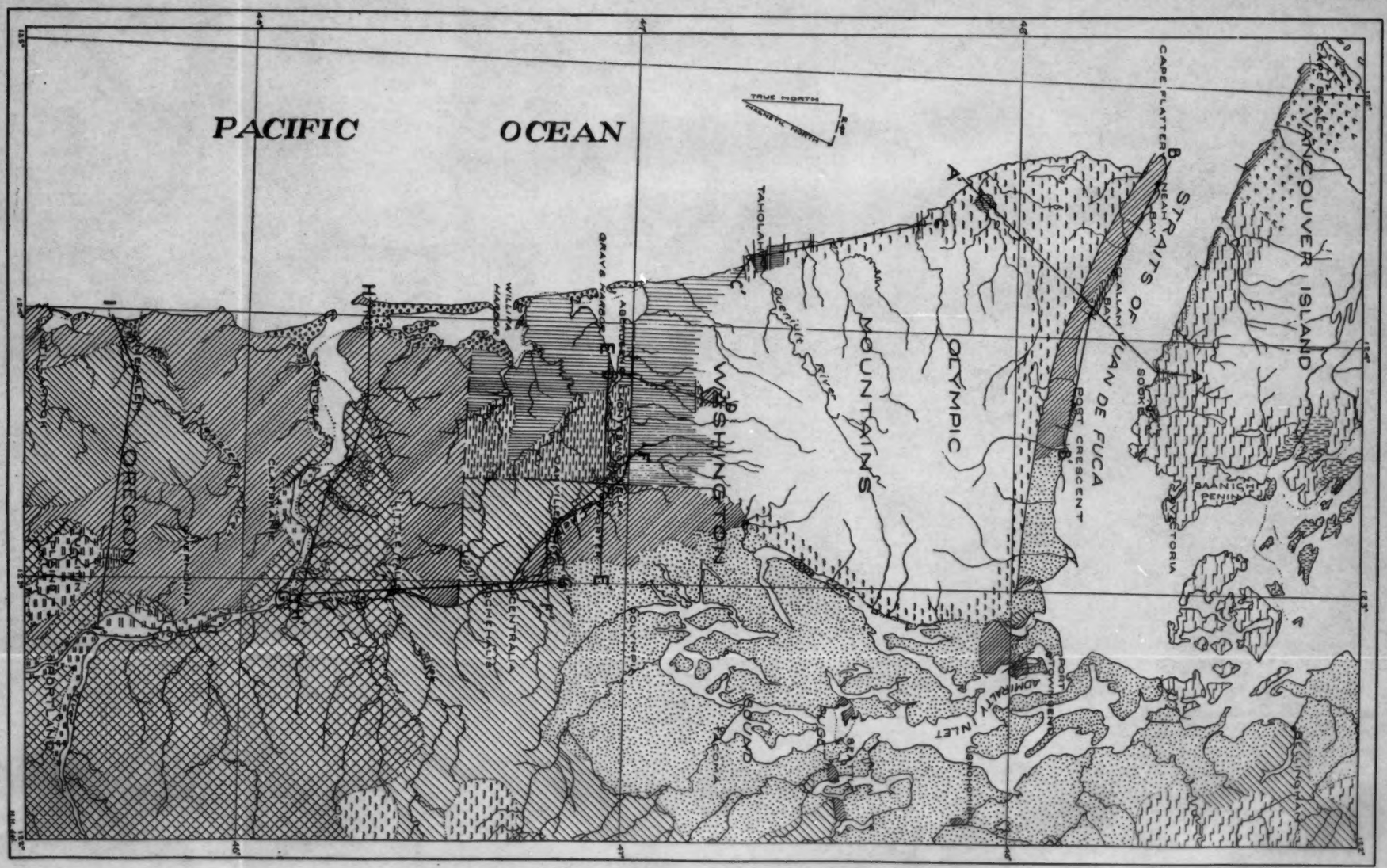
COLUMNAR SECTION OF PUGET SOUND AND THE SAN JUAN ISLANDS.

	Saanich formation, 50′
	Vashon drift
	Admiralty till
Astoria Series	*Seattle formation* conglomerates and tuffaceous sandstones and shales of the Seattle monocline. 4,000′
	San Lorenzo formation tuffaceous sandstones and shales with basalts and andesites at base, of Bean Point and Port Townsend. 5,000′
Tejon Series	*Olequa formation* tuffaceous lignitic sandstones and shales of marine and estuarine origin forming the coal series of Whatcom County and the upper 12,000′ of the Pierce County section.
	Chehalis formation tuffaceous lignitic sandstones and shales of marine and estuarine origin of Fairfax and the Pierce County coal field. 5,000′
	Bedrock complex

COLUMNAR SECTION OF THE STRAITS OF FUCA AND WEST COAST OF THE OLYMPIC PENINSULA.

	Admiralty till
	Merced formation, 400′
	Empire formation sandstones of Bogochiel River, tuffaceous shale of Taholah. 1,600′
	Monterey formation lignitic sandstone of Clallam Bay section. 2,000′
Astoria Series	*Twin River formation* clay shales of Twin River section. 2,000′
	Seattle formation tuffaceous shale and sandstone of Sekin River and Gettysburg. 3,000′
	San Lorenzo formation tuffaceous shale and sandstone of southwest coast of Vancouver Island, heavy conglomerates of the Cape Flattery section. 17,000′

	Sooke formation sandstones and conglomerates of Muir Creek. 1,600′
Tejon Series	*Arago formation* basalt tuffs of Port Crescent and west of Discovery Harbor. 3,000′
	Bedrock complex



Geologic Map of the Tertiary Deposits of the North Pacific Coast of the United States and Southern Vancouver Island. For explanatory symbols see Plate XXXVIII.

GEOLOGIC MAP OF THE TERTIARY DEPOSITS OF THE NORTH PACIFIC COAST OF THE UNITED STATES AND SOUTHERN VANCOUVER ISLAND

By

Ralph Arnold and Harold Hannibal

SCALE 0 10 20 30 40 50 60 70 80 Miles
0 10 20 30 40 50 60 70 80 Kilometers

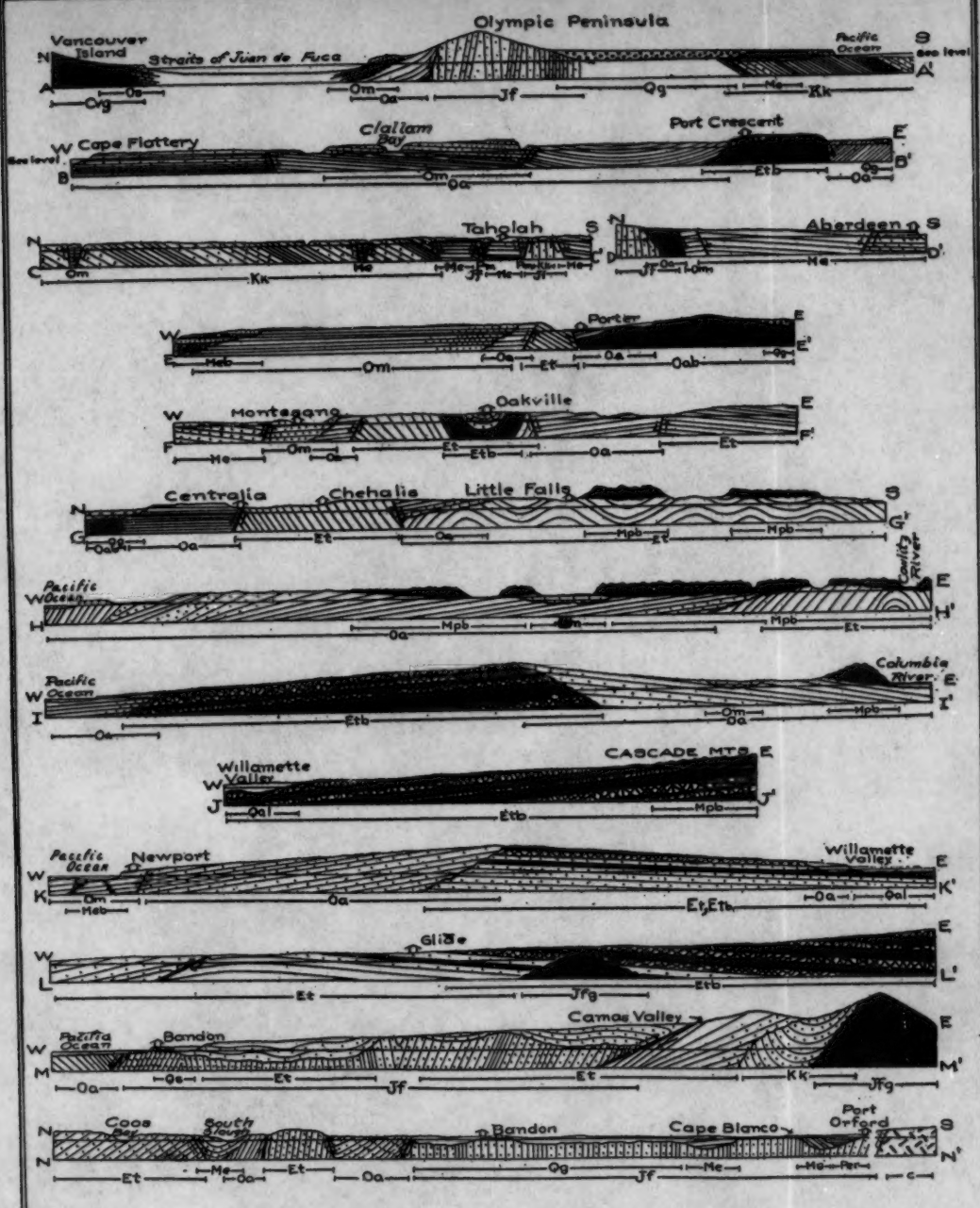
LEGEND

Quaternary and Post-Quaternary:
- Alluvial deposits
- Raised beach (Saanich) and sandspit deposits
- Glacial deposits

Pliocene and Upper Miocene:
- Elk River, Merced – Pliocene.
- Basic flows and tuffs

Middle Miocene:
- Empire –

Oligocene–Miocene:
- Monterey–
- Astoria series–Middle Oligocene.
- Scooba – Middle Oligocene.
- Tejon – Middle Eocene.
- Chico – Upper Cretaceous.
- Knoxville, Franciscan – Undifferentiated Lower Cretaceous and Jurassic.
- Granite – Post-Vancouver
- Vancouver series–Carboniferous with some Triassic, including undifferentiated Paleozoics of the Cascade and Klamath mountains.



GEOLOGIC SECTIONS OF THE TERTIARY DEPOSITS OF THE NORTH PACIFIC COAST OF THE UNITED STATES AND SOUTHERN VANCOUVER ISLAND

By
Ralph Arnold and Harold Hannibal

Meters 1500 1000 500 — Feet 5000 4000 3000 2000 1000

0 5 10 15 Miles
0 5 10 15 20 25 Kilometers

LEGEND

Qal Alluvial deposits	Mpb Upper Miocene and Pliocene basalts	Oab Astoria basalts	Jfg Franciscan greenstones and serpentine
Qs Raised beach deposits	Me Empire	Os Sooke	Jf Franciscan
Qg Glacial deposits	Mb Empire basalts	Et Tejon	Cvg Vancouver greenstones
Per Elk River	Om Monterey	Etb Tejon basalts	C Colebrook schist
Pm Merced	Oa Astoria	Kk Knoxville	

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GEOLOGIC SECTIONS
OF THE
TERTIARY DEPOSITS
OF THE
NORTH PACIFIC COAST
AND
SOUTHERN VANCOUVER ISLAND
BY
Ralph Arnold and Harold Hannibal

General Remarks.

The recognition of marine tertiary on the North Pacific Coast of America dates back to 1848 when Conrad[1] described several fossil mollusca from "the tertiary deposits on the Columbia River near Astoria." More recent studies by Richardson, Condon, Diller, Willis and Smith, the senior author, and other writers too numerous to mention have shown that such rocks underlie all of Oregon west of the Cascade Range and north of the Klamath-Siskiyou Mountains, western Washington except the Olympic Range, and portions of Vancouver Island. The several geological horizons have in most instances been named and something is known of their fossil contents but their stratigraphic relations one to another and their correlatives among the closely related formations of California are scarcely understood.

Several years ago the senior writer visited the more important fossil localities then known in western Oregon and Washington in the interests of the United States Geological Survey. No general report of the work was published owing to the necessity of further field studies but descriptions of the stratigraphy of particular districts are to be found in "Gold Placers of the northwestern coast of Washington,"[2] "Coal in Clallam County, Washington"[3] and "A Geological Reconnaissance of the Olympic Peninsula."[4] Some of the palæontological material obtained was described in "The Tertiary and Quaternary Pectens of California,"[5] "Descriptions of New Cretaceous and Tertiary Fossils from the Santa Cruz Mountains, California"[6] and "The Miocene of Astoria and Coos Bay, Oregon."[7] The distribution of land and water in this region during the different tertiary periods is treated of in a preliminary way in "Environment of the Tertiary Faunas of the Pacific Coast of the United States."[8]

[1] *Amer. Jl. Sci.*, 2d series, V., 1848, p. 432.

[2] Arnold, R., Bull. 260, U. S. Geol. Sur., 1905, p. 154–7, Fig. 11.

[3] Ibid., p. 413–421.

[4] Arnold, R., *Bull. Geol. Soc. Am.*, XVII., 1906, p. 451–468, Pl. 55–58.

[5] Arnold, R., Prof. Pap. 47, U. S. Geol. Sur., 1906, 264 pp., 53 Pl.

[6] Arnold, R., Proc. U. S. Nat. Mus., XXXIV., 1908, p. 345–390, Pl. XXXI.–XXXVII.

[7] Dall, W. H., Prof. Pap. 59, U. S. Geol. Sur., 1909, 284 pp., 23 Pl.

[8] Arnold, R., *Jour. of Geol.*, XVII., 1909, p. 509–533.

In 1911 the junior writer was commissioned to continue the exploration at private expense and the months of June, July, and August were spent in examining the various described sections and districts of the Oregon coast and western Washington. With the opening of the spring of 1912 as opportunity offered, short trips were undertaken from Seattle to points about Puget Sound and the Straits of Fuca, and three weeks were spent on the southwest coast of Vancouver Isand. In June extended field work was resumed and a trip made from Port Townsend west to Cape Flattery along the north coast of Washington, following which two months were spent in southwestern Washington. Six weeks more were given over to further collecting in western Oregon, field work being concluded in October.

The present paper, preliminary to more extended accounts of the stratigraphy and palaeontology, is based primarily on the work done in 1911 and 1912. The faunas listed here include described species obtained at, or in the vicinity of, the several type sections or, if the deposits are referred to formations described first from California, characteristic faunas from some district on the North Pacific Coast in lieu.

Bedrock Complex.

The bedrock complex on which the marine tertiary deposits were laid down varies widely from place to place.

In southern Oregon the underlying rocks are chiefly Mesozoic, the Franciscan (Myrtle in part), Dothan, and Galice formations of Jurassic age, and the Knoxville (Myrtle in part), Horsetown, and perhaps also Chico formations which are Cretaceous (the Knoxville may extend into Jurassic). These have been partially described by Diller[9] and Londerback[10] though much work still needs to be done to elucidate the complicated stratigraphy.

In the Olympic Mountains the Tertiary rests indiscriminately

[9] Roseburg Folio, No. 49, U. S. Geol. Sur., 1898; Port Orford Folio, No. 89, U. S. Geol. Sur., 1903; Mesozoic Sediments of Southwestern Oregon, *Am. Jour. Sci.*, XXIII., 1907, p. 401–421; "Strata containing the Jurassic Flora of Oregon," *Bull. Geol. Soc. Am.*, XIX., 1908, p. 367–402.

[10] "The Mesozoic of Southwestern Oregon," *Jour. of Geol.*, XIII., 1905, p. 514–555.

FIG. A.

FIG. B.

FIG. A. Point of the Arches from Shi Shi Beach near Neah Bay, Washington. A characteristic exposure of Franciscan rocks such as form the Olympic complex.

FIG. B. Diabase flow intercalated in Arago beds (Tejon series) on Umpqua River near Glide, Oregon.

upon indurated shales, sandstones, and conglomerates of supposed Cretaceous age[11] and a great complex of metamorphic sandstone, shale, radiolarian chert, glaucophane schist, and greenstones cut by peridotite serpentine, a series closely resembling the Franciscan of southern Oregon and the California Coast Ranges.

In the Cascade Mountains of Oregon and southern Washington the contacts between the tertiary and older rocks are usually obscured by outpourings of lava but farther north Russell[12] has described Mesozoic and older sediments associated with granite, greenstones and serpentine.

On Vancouver Island the Vancouver Series underlies the Oligocene; it is composed of slates, limestones, and greenstone-diorites of supposed Carboniferous and perhaps also Triassic age, cut by biotite granite. This has been described by George M. Dawson.[13] Farther north in the Straits of Georgia Chico rocks have a wide distribution.

Eocene Deposits—The Tejon Series.

Eocene deposits form a large proportion and from an economic standpoint the most important part of the Tertiary sediments of western Oregon and Washington. These belong so far as known exclusively to the Tejon Series. Everywhere that a contact has been observed the Tejon lies directly on the pre-tertiary rocks, so it appears that the Martinez formation (early Eocene) of California is not represented on the north Pacific coast. In addition to being the most widespread formation the Tejon is the most extensively developed. Prevailing low dips render it impossible to study it conveniently in any one section, but from data obtained in the coal field of Pierce County, Washington, and several other partial sections it is probable that 15,000 feet is not too great an estimate of the thickness of the series in western Washington, while in Oregon at least 13,000 feet of beds stratigraphically higher are present. This

[11] Arnold, R., *Bull. Geol. Soc. Am.*, XVIII., 1906, p. 459.

[12] "A Preliminary Paper on the Geology of the Cascade Mountains in Northern Washington," 20th Ann. Rept. U. S. Geol. Sur. (II), 1900, p. 83–210.

[13] 2d Ann. Rept. Geol. Sur. Can., 1887, p. 10*B*–13*B*.

extraordinary development of sediments is only to be explained by a consideration of the nature of the deposits. These are at some points coarse basalt tuffs and at others, and by all odds this is the most prevalent type of sedimentation, worked over volcanic ejectmenta in the form of sandstones or shales deposited under estuarine conditions, evidently with considerable rapidity.

Three divisions, the Chehalis, Olequa, and Arago formations, represent well-marked palæontological horizons that can be recognized by characteristic faunas and floras over the North Pacific Coast. The latter is not found in juxtaposition with the Chehalis and Olequa and may represent a later phase of the Eocene equivalent to the Ione of California.

Faunal Divisions of the Tejon Series.

Tejon Series	Arago formation—zone of *Venericardia horni* variety with obsolete ribs		Tropical flora—fan-palms, magnolias, figs, and ferns.
	Olequa formation	zone of *Venericardia horni* Gabb[14]	Austral flora—birches, sycamores and chestnuts.
	Chehalis formation		

The Chehalis and Olequa formations usually consist of fine material and are essentially estuarine deposits throughout, containing numerous lignite beds interstratified with alternating fresh water and marine sediments. The Arago of the Coos Bay-Port Orford coal fields is similar but commonly consists of coarser material partly arkose in character. Farther north in Oregon this horizon is represented by basic flows and coarse bedded tuffs occasionally carrying marine fossils. In the Roseburg district it is essentially tuffaceous sandstone of marine origin. Coarse basalt tuffs carrying marine fossils and interbedded with basic flows and a subordinate amount of sandstone on the north coast of Washington are also referred to this horizon on the basis of palaeontological evidence.

[14] Usually cited as *V. planicosta* Lam., but the real *planicosta* is confined to the Martinez formation on the Pacific Coast.

Table of Correlation of the Tertiary and Quaternary Horizons of the Pacific Coast.

Age.	North Pacific Coast.		California.	
	Formation.	Chief Zone Fossils.	Formation.	Chief Zone Fossils.
Pleistocene			Upper San Pedro	
	Saanich		Lower San Pedro	
	Vashon Drift			
	Admiralty Till			
Pliocene	Elk River	*Cardium corbis* Mart. *Scutella oregonensis* Clark *Turris smithi* Arn.	Deadman Island (Santa Barbara Pliocene)	*Echinarachnius excentricus* Esch. *Turris smithi* Arn. *Turritella jewetti* Cpr.
	Merced	*Pecten dilleri* Dall *Scutella oregonensis* Clark	Merced, Purisima (in part), and Etchegoin	*Pecten healeyi* Arn. *Echinarachnius Gibbsi* Rem. *Scutella oregonensis* Clark *Scutella interlineata* Stimp
Miocene			Santa Margarita	*Astrodapsis antiselli* Conr. *Astrodapsis whitneyi* Gabb *Tamiosoma gregaria* Conr.
		Scutella gabbi Rem. *Argobuccinum cammani* Dall *Mytilus middendorffi* Grnk. *Cardium coosense* Dall *Pecten coosensis* Shum. *Bullia bogackielii* Rgn.	*Scutella gabbi–S. breweriana* beds	*Astrodapsis antiselli* Conr. *Scutella gabbi* Rem. *Scutella breweriana* Gabb
	Empire			
		Pecten propatulus Conr. *Arca devincta* Conr.		*Pecten propatulus* Conr. *Arca devincta* Conr.
	Monterey (Clallam)	*Polinices saxea* Conr. *Venus clallamensis* Rgn. *Turritella oregonensis* Conr.	Monterey (Temblor)	*Ficus kernianus* Cooper *Agasoma barkerianum* Cooper *Polinices saxea* Conr.
		Acila gettysburgensis Rgn.		*Pecten magnolia* Conr.
Oligocene	Astoria — Twin River	*Polinices olympidii* Rgn. *Turritella oregonensis* Conr.	Vaqueros	*Turritella inezana* Conr.
	Astoria — Seattle	*Acila gettysburgensis* Rgn. *Turcicula washingtoniana* Dall *Macrocallista vespertina* Conr.		
	Astoria — San Lorenzo	*Acila shumardi* Dall *Turcicula columbiana* Dall *Pecten branneri* Arn.	San Lorenzo	*Acila shumardi* Dall *Acila dalli* Arn. *Pecten branneri* Arn.
	Sooke	*Pecten branneri* Arn. *Macrocallista newcombei* Mrm. *Patella geometrica* Mrm.		
	Arago	*Venericardia horni* Gabb (obsolete ribbed variety)	Ione	*Venericardia horni* Gabb (obsolete ribbed variety)
Eocene	Tejon — Olequa	*Venericardia horni* Gabb *Pecten landesi* Arn.	Tejon	*Venericardia horni* Gabb
	Tejon — Chehalis	*Venericardia horni* Gabb *Meretrix californica* Gabb		
			Martinez	*Venericardia planicosta* Lam *Pholadomya nasuta* Gabb

The Chehalis Formation.

The term Chehalis sandstone was used by Lawson[15] for some arenaceous bedded tuffs containing marine Eocene fossils exposed in a water tunnel through the hill east of the city of Chehalis, Washington. The beds here form an intregal part of the south limb of an anticline in which several thousand feet of conformable strata are involved, the friable nature of the rock rendering an exact estimate of the thickness difficult without instrumental measurements. The upper beds exposed by this anticline are distinctly marine while the lowest are probably of freshwater origin judging by the presence of workable coal seams.

This anticline is in turn one of a series of folds whose axes have a general east-west trend, exposed along the lower slopes of the Cascade Range east of the Portland-Tacoma railway from a few miles south of the Cowlitz River northward to Tenino. Upwards of 10,000 feet of bedded tuffaceous and lignite-bearing sandstones and shales, to a large degree of estuarine or freshwater origin, but with frequent local zones of marine fossiliferous sediments, are involved in this folding.

Other areas of the Chehalis formation are the Balch syncline west of Chehalis and Centralia, the King County coal fields extending from Allentown in the Duwamish Valley eastward and southward beneath the glacial drift to Renton, Green River, Newcastle, and Squak Mountain, and the lowest 2,000 feet of Eocene in the Pierce County coal field, the beds in which the Fairfax and Montezuma mines are located.

No equivalent strata have been recognized elsewhere in the northwest but the Tejon of the type locality near old Fort Tejon in California evidently represents the same faunal stage. In many respects the Chehalis fauna is similar to that of the succeeding Olequa formation, but the floras are markedly different, that of the Chehalis formation lacking the distinctly tropical facies of the later divisions of the Tejon, and thus affording a most characteristic feature.

[15] *Am. Geol.*, XIII., 1894, p. 437.

Excellent plant localities occur at Steel's Crossing near Allentown, the Fairfax and Montezuma mines on Carbon River, Delazine Creek near Elma, and Skookum Chuck Canon below Bucoda. The Taylor clay mine on Green River, Snoqualmie Pass, the Newcastle mine east of Lake Washington, and a point in the hills south of where the Centralia-Oakville fault crosses Lincoln Creek are also said to have contributed fossil plants belonging to this horizon.

The following marine invertebrate fauna has been obtained from the Chehalis formation.

The Olequa Formation.

Overlying the Chehalis beds is a horizon of the Tejon Series which on Olequa Creek in southern Lewis and northern Cowlitz counties, Washington, contains an excellent flora, and also marine and freshwater faunas. The type section extends from the Erwing ranch a little over two miles above Little Falls southward down Olequa Creek to Olequa, a distance of about five and one-half miles. The beds immediately below Erwing's represent a low east-west syncline in which marine beds are overlain by freshwater deposits, and these in turn by plant-bearing shales. Down the river a low anticlinal axis crosses Olequa Creek a little above Little Falls in the heart of which other freshwater and marine beds are exposed. At the railroad bridge below Little Falls the upper marine and freshwater beds reappear dipping southward and some distance above them in nearly horizontal strata appears a thin zone of coarse basalt tuff containing numerous marine fossils near the old railroad bridge above Olequa. From here southward the Eocene is mantled by Pliocene basalts associated with river gravels.

The same horizon of the Eocene reappears, however, at Castle Rock and farther west on Coal Creek above Stella in a more or less regular repetition of low folds with east-west axes. Probably the total thickness of beds in this district does not represent more than 2,000 or 3,000 feet.

The flora is noteworthy for the abundance of a large palm, probably *Calamopsis* cf. *danae* Lx. and of *Magnolia* cf. *Californica* Lx. As both these species and one or two others identical with Olequa

Partial List of Species in the Chehalis Horizon of the Tejon Series (Middle Eocene) on the Cowlitz River and Bordering the Chehalis Valley, Washington.

	57	58	113	145
PELECYPODA:				
Avicula pellucida Gabb			×	
Cardium breweri Gabb		×	×	
Corbula horni Gabb		×	×	
Crassitellites compacta Gabb			×	
Crassitellites grandis Gabb	×			
Crassitellites uvasana Conr			×	
Macrocallista conradiana Gabb		×		
Marcia quadrata Gabb			×	
Meretrix californica Conr.[16]	×			×
Meretrix horni Gabb	×	×	×	
Meretrix ovalis Gabb	×			
Meretrix uvasana Conr				×
Miltha turneri Stanton	×			
Modiolus ornatus Gabb	×	×		
Ostrea idriœnsis Gabb	×	×	×	
Solen parallelus Gabb	×	×		
Tellina horni Gabb			×	
Tellina longa Gabb	×		×	
Tellina remondi Gabb	×			
Venericardia horni Gabb[16]	×	×	×	
GASTEROPODA:				
Amauropsis alveata Conr			×	
Ancillaria bretzi Wvr			×	
Calyptræa excentrica Gabb	×	×	×	
Conus remondi Gabb[16]			×	
Crepidula pileum Gabb		×	×	
Exilia diabloi Gabb[16]			×	
Ficopsis horni Gabb			×	×
Gyrineum washingtonianum Wvr			×	
Mitra washingtoniana Wvr			×	
Morio tuberculatus Gabb			×	×
Murex sopenahensis Wvr			×	
Olivella mathewsoni Gabb			×	
Perissolax washingtoniana Wvr[16]		×	×	×
Polinices horni Gabb	×	×	×	×
Polinices secta Gabb		×	×	
Pseudoliva volutæformis Gabb		×		
Rimella simplex Gabb			×	
Sinum obliquum Gabb	×	×	×	
Strepsidura whitneyi Gabb	×		×	
Thais eocenica Wvr			×	
Tritonium cowlitzense Wvr			×	
Turris fresnoensis Arn			×	
Turris io Gabb			×	
Turris sinuata Gabb[16]			×	×
Turritella uvasana Conr	×	×	×	×
SCAPHOPODA:				
Dentalium cooperi Gabb		×		×
Dentalium stramineum Gabb	×	×	×	×
CEPHALOPODA:				
Aturia mathewsoni Gabb			×	

[16] Species supposed to be characteristic of this horizon.

Locality 57; sandstone, cuts along O. W.-Milwaukee Railway east of Balch, Washington. (H. Hannibal.)

Locality 58; shaly sandstone, bluffs along Olequa Creek at old Ainslee Mill below Winlock, Washington. (H. Hannibal.)

Locality 113; shaly sandstone, bluffs along Cowlitz River below mouth of Drew Creek, 1½ miles east of Olequa, Washington. (H. Hannibal.)

Locality 145; shaly sandstone, water-tunnel on hill east of Chehalis, Washington. (H. Hannibal.)

Partial List of Species in the Olequa Horizon of the Tejon Series (Middle Eocene) at Little Falls, Washington.

	65	66	68	70	73	74	75
PELECYPODA:							
Avicula pellucida Gabb	...	...	×	...	...	...	...
Barbatia morsei Gabb	×	...	×	...	...	×	...
Cardium breweri Gabb	×	×	...	...	×	...	...
Cardium olequæensis Wvr.[17]	...	×	×	×	...	×	...
Crassitellites compacta Gabb	...	...	...	...	...	×	...
Crassitellites grandis Gabb	...	...	...	×	...	...	...
Crassitellites washingtoniana Wvr.[17]	...	...	×	...	×	...	...
Cyrena brevidens White	...	...	×	...	...	...	...
Macrocallista conradiana Gabb	×	...	×	×	...	...	...
Marcia quadrata Gabb	×	...	...	...	...	...	...
Modiolus ornatus Gabb	×	...	...	×	×	...	...
Ostrea idriænsis Gabb	×	×	×	×	...	×	×
Pecten landesi Arn.[17]	...	×	...	×	...	...	...
Septifer dicrotomus Gabb	...	...	...	×	...	...	...
Solen parallelus Gabb	...	×	...	...	×	...	...
Tellina horni Gabb	...	×	...	...	...	...	...
Venericardia horni Gabb[17]	×	×	×	...	×	×	×
GASTEROPODA:							
Amauropsis alveata Conr.	×	×	...	...	×	...	...
Calyptræa excentrica Gabb	×	...	×	×	×	...	×
Ficopsis horni Gabb	×	×	...	×	×	...	...
Ficus mamillatus Gabb	...	×	...	...	...	...	...
Polinices horni Gabb	...	×	×	×	...	...	...
Polinices secta Gabb	...	×	×	...	×	...	...
Pseudoliva volutæformis Gabb	...	×	...	...	×	...	...
Rimella simplex Gabb	×	×	...	×	...	...	...
Sinum obliquum Gabb	...	×	×	...	...	...	...
Turritella uvasana Conr.	×	...	×	×	×	×	...
SCAPHOPODA:							
Dentalium cooperi Gabb	...	...	×	...	...	...	...
Dentalium stramineum Gabb	×	×	×	...	...	...	...

[17] Species supposed to be characteristic of this horizon.

Locality 65; sandstone, bluffs along Olequa Creek between falls and town, Little Falls, Washington. (H. Hannibal.)

Locality 66; tuffaceous sandstone, bluffs at junction of Olequa and Stillwater Creeks, Little Falls, Washington. (H. Hannibal.)

FIG. A.

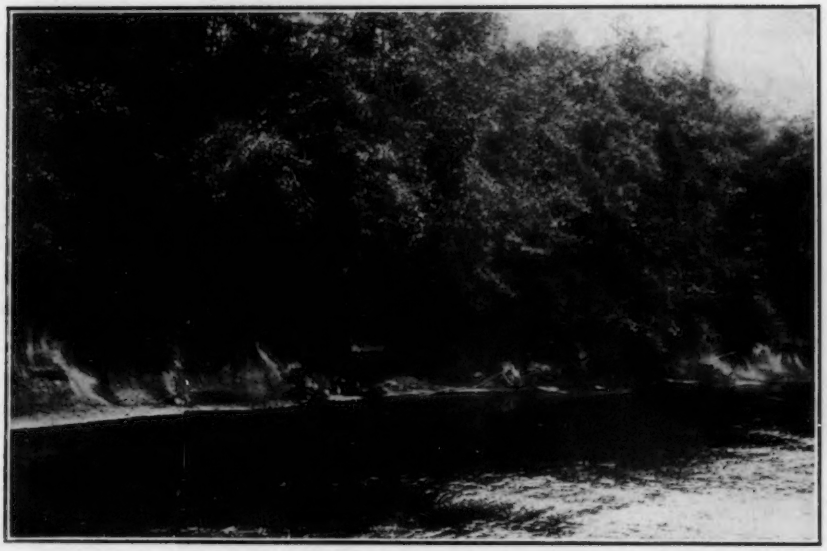

FIG. B.

FIG. A. Steeply tilted Arago beds (Tejon series) at Mussel Reef west of Coos Bay, Oregon.

FIG. B. Olequa beds (Tejon series) near old log dam on Stillwater Creek, Little Falls, Washington.

Locality 68; sandstone and tuffaceous marl, bluffs on Stillwater Creek at old logdam and for one fourth of a mile below, Little Falls, Washington. (H. Hannibal.)

Locality 70; tuffaceous sandstone, bluffs along Stillwater Creek three fourths of a mile west of junction with Olequa Creek, Little Falls, Washington. (H. Hannibal.)

Locality 73; basalt tuff, cut on Portland-Tacoma railway two and one half miles south of Little Falls, Washington. (H. Hannibal.)

Locality 74; sandstone, gulch below Backstrom ranch, Brim Creek, Little Falls, Washington. (H. Hannibal.)

Locality 75; lignitic sandstone, bluffs three fourths of a mile above Con Murphy ranch on Stillwater Creek, Little Falls, Washington. (H. Hannibal.)

forms are present in the Swauk formation at Liberty, Washington, it is probable that the two deposits on opposite sides of the Cascade Mountains are approximately contemporaneous.

An excellent plant locality in the Olequa formation occurs on Olequa Creek above Little Falls, another is situated in the hills west of Castle Rock. The plant localities at the Carbonado and Wilkeston coal mines, South Prairie Creek above the Burnett Mine, the Bellingham and Lake Whatcom mines, and near Maple Falls on Mt. Baker may be referable to this horizon.

The following marine fauna was collected on Olequa and Stillwater Creeks near Little Falls.

Arago Formation.

The type section of the Arago formation[18] is taken across the strike of a steeply tilted fault-block which may be estimated to include approximately 10,000 feet of alternating marine and freshwater sediments, partly arkose and partly tuffaceous in character, without the base or top of the formation being exposed. A much larger area in which more than 15,000 feet of sediments are represented extends eastward from Coos Bay to the base of the Cascade Mountains and northward along the west flank of the Cascades and through the heart of the Coast Range, besides underlying and outcropping in the Willamette Valley across which the formation was once continuous. In the northward extension of the Arago in Oregon the sedimentary deposits become more and more replaced

[18] See J. S. Diller, Coos Bay Folio, No. 73, U. S. Geol. Sur., 1901.

by basic volcanic flows and agglomerates, until on the Santiam River east of Albany and the Nehalem River in Clatsop and Columbia Counties only igneous rocks are present, the few fragmentary fossils on which the determination of the age of these lavas is based being obtained from coarse tuffs.

Partial List of Species in the Arago Horizon of the Tejon Series (Middle Eocene) of Southwestern Oregon and the North Coast of Washington.

	32	33	40	99	116	154
PELECYPODA:						
Cardium breweri Gabb	...	...	...	×	×	...
Cardium cooperi Gabb	...	...	...	×	...	...
Corbula horni Gabb	...	...	...	×	×	...
Crassitellites compacta Gabb	...	...	...	×	...	...
Crassitellites uvasana Conr	×	...	...	×	...	...
Cyrena brevidens White	...	×	...	...	...	...
Glycymeris cor Gabb[21]	...	...	...	×	×	...
Macrocallista conradiana Gabb	×	...	...	×	×	...
Marcia quadrata Gabb	...	...	...	...	×	...
Meretrix horni Gabb	...	×	...	...	...	...
Miltha turneri Stanton	...	×	...	...	...	...
Modiolus ornatus Gabb	×	×	...	×	×	...
Ostrea idriensis Gabb	...	×	...	×	×	×
Septifer dichrotomus Gabb	...	...	...	...	×	...
Solen parallelus Gabb	×	...	...	×	...	...
Tellina horni Gabb	×	...	...	...	...	...
Tellina longa Gabb	...	×	...	...	...	...
Tellina remondi Gabb	×	×	...	...	...	...
Venericardia horni Gabb (var. with obsolete ribs)[19]	×	...	...	×	×	×
GASTEROPODA:						
Amauropsis alveata Conr	...	...	...	×	×	...
Calyptræa excentrica Gabb	...	...	...	×	×	...
Conus sinuatus Gabb	...	...	...	×	...	...
Ficopsis horni Gabb	×	...	...	×	...	...
Loxotrema turrita Gabb	...	...	...	×	...	...
Olivella mathewsoni Gabb	...	...	...	×	...	...
Polinices globosa Gabb[21]	...	...	...	...	×	...
Polinices horni Gabb	×	...	...	...	...	...
Polinices shumardiana Gabb[21]	...	...	...	×	×	...
Potamides carbonicola Cooper[21]	...	...	...	×	...	...
Sinum obliquum Gabb	×	...	...	...	...	...
Strepsidura whitneyi Gabb	×	×	...	...	...	...
Tritonium californicum Gabb	...	...	...	...	×	...
Turris io Gabb	×	...	...	...	...	...
Turritella uvasana Conr	×	...	×	×	×	...
SCAPHOPODA:						
Dentalium stramineum Gabb	×	×	...	...	...	...
BRACHIOPODA:						
Terebratulina tejonensis Stanton	...	...	...	...	...	×

[19] Species supposed to be characteristic of this horizon.

Locality 32; sandstone and shale, seacliffs between mouth of Big Creek and Cape Gregory, Coos Bay, Oregon. (H. Hannibal.)

Locality 33; sandstone and shale, seacliffs at Mussel Reef between Coos Head and Cape Gregory, Coos Bay, Oregon. (H. Hannibal.)

Locality 40; sandstone, one fourth of a mile below top of grade north of Five-mile Creek, Bandon, Oregon. (H. Hannibal.)

Locality 99; tuffaceous sandstone, bluffs along Little River at junction with north fork of Umpqua River, Glide, Oregon. (H. Hannibal.)

Locality 116; basalt tuff, seacliffs between pier and Point Crescent, Port Crescent, Washington. (H. Hannibal.)

Locality 154; basalt tuffs, seacliffs immediately southwest of Tongue Point, Port Crescent, Washington. (H. Hannibal.)

On the north coast of Washington the senior author[20] has termed a series of coarse heavy-bedded basalt tuffs with intercalated flows and a minor element of sandstone the Crescent formation. Collections of fossils from the tuff and sandstone obtained by the junior author in 1912 indicate that this formation is the stratigraphic equivalent of the Arago.

The Benton County hills a mile north of Granger, Oregon, Mary's Peak near Philomath, the Willamette River above Springfield, and the north Santiam River between Lyons and Kingston have yielded excellent plant remains pertaining to this horizon, usually in a white or pink rhyolite tuff intercalated with the basalts. Knowlton[21] has also described plants from a locality in the Arago near Comstock in Douglas County and another on Coal Creek in Lane County. Several near Ashland may represent the same horizon.

The following fauna was obtained from the type section south of Coos Bay and from points on the Umpqua River, Oregon, and the north coast of Washington.

Oligocene Deposits—the Status of the Oligocene of the Pacific Coast.

Until a comparatively few years ago the tertiary of the Pacific Coast was classified on a three-fold basis—Eocene, Miocene and Pliocene, and the term Oligocene was a vague indefinite division

[20] Arnold, R., *Bull. Geol. Soc. Am.*, XVII., 1906, p. 460.

[21] 20th Ann. Rept. U. S. Geol. Sur., Pt. III., 1900, pp. 37–64, Pl. I.–V.; Bull. 204, U. S. Geol. Sur., 1902, p. 111.

recognized by European geologists, but no equivalent strata were known on the Pacific Coast. In 1898 Dall[22] used the term Oligocene for the first time in connection with Pacific Coast stratigraphy to cover the "*Aturia* bed," Astoria shales, and doubtfully (and correctly so since it is not a homogenous formation) the Tunnel Point beds of the Oregon Coast. Following this the senior writer[23] placed the San Lorenzo formation of California in the Oligocene on the basis of its equivalence to strata referred to that period on the north Pacific Coast.

Were the Pacific Coast Tertiary the standard for the world it is obvious that a three-fold division would be recognized. The lowest member would consist of the Martinez and Tejon, equivalent to the present Eocene. The succeeding division would embrace the Sooke, Astoria, Vaqueros, and Monterey and correspond to what has been commonly called Oligocene and Lower Miocene. The third would include the numerous usually local formations of which the Empire is the oldest and the Elk River and Deadman Island or Santa Barbara Pliocene the youngest, in other words the middle and upper Miocene and Pliocene, there being no well-marked hiatus in this part of the world between beds of Miocene and Pliocene age, as these divisions are currently recognized.

A direct correlation between the Pacific Coast marine Tertiary and the deposits of Europe and bordering the Gulf of Mexico is impossible owing to the almost total absence of identical species except in the Eocene. The nummulites and corals which have been depended upon to establish the contemporaneity of the Oligocene of Europe and the Antilles are not known on the Pacific Coast, and there do not appear to be any other forms that will serve the purpose. However an assumption that approximately the same time interval is represented by the Pacific Coast deposits may be based on certain broad resemblances.

In the closely allied succession of strata commencing with the Sooke and terminating with the Monterey, the oldest beds lack so

[22] "A Table of North American Tertiary Horizons Correlated with One Another and Those of Western Europe with Annotations," 18th Ann. Rept. U. S. Geol. Sur. (II.), 1898, p. 323–348.

[23] Prof. Pap. 47, U. S. Geol. Sur., 1906, p. 15 ff.

far as known any recent species of mollusca while the number gradually increases to about 6 per cent. of the fauna in the Monterey. The proportion of species extending from the Monterey into the Middle Miocene is somewhat greater—perhaps 25 per cent. Two or three long-lived species known in the Eocene range through the entire Sooke-Monterey succession. With two notable exceptions, the Sooke and Twin River formations, this entire succession is decidedly subtropical in facies. There is a conspicuous element of distinctly Eocene-Oligocene genera throughout, such as *Crassitellites, Aturia, Molopophorus, Exilia, Perissolax, Priscofusus, Strepsidura,* and giant Turritellas, associated with an exceptionally large number of species of *Turris, Patella, Barbatia, Macrocallista, Eudolium,* giant Limas, and other usually tropical genera unknown or of exceptional occurrence in the later deposits of the district.

This Oligocene facies of the fauna is very obvious in the Sooke and Astoria, but less marked in the Vaqueros owing to the additional presence of *Lyropecten* and giant Ostreas, typical Miocene types which, however, must have had their beginning in earlier strata to have become so widespread and important an element of the Miocene fauna. The Monterey is faunally closely allied to these other beds by numerous identical species, but as far as our present knowledge goes, might be placed equally well in the latest Oligocene or the earliest Miocene on the basis of the general faunal facies.

The Sooke Formation.

Occupying several disconnected areas along the south coast of Vancouver Island from Becher Bay westward to Sombrio River near Port San Juan and perhaps farther, is a formation originally described as probably upper Miocene owing to the boreal type of fauna. This Merriam[24] has termed the Sooke beds. With the exception of the type area between Muir and Coal Creeks several miles west of Sooke where drillings have shown the sediments to be more than 1,500 feet thick, the beds comprise only a few feet of basal conglomerate usually less than the height of the sea cliffs in thickness. These lie directly on the bedrock complex, the Van-

[24] Bull. Dept. Geol. Univ. Cal., II., 1896, p. 101–8.

couver greenstone-diorites, and on Muir Creek a mile or two back from the coast the greenstone is exposed beneath the Sooke in the bed of the Cañon so that the development of the sedimentaries on the coast is evidently only local.

The following fauna was obtained from this formation.

Partial List of Species in the Sooke Formation (Middle Oligocene) of the Southern Coast of Vancouver Island.

	129	130	131
PELECYPODA:			
Macrocallista mathewsoni Gabb.	×	.....	×
Macrocallista newcombei Mrm.[24a]	×	.....	.....
Mytilus sammamishensis Wvr.	×	×	×
Ostrea idriænsis Gabb.	×	×	×
Pecten branneri Arn.[24a]	×	×	×
Phacoides acutilineatus Conr.	.....	.....	×
Solen curtus Conr.	×	.....	.....
Spisula albaria Conr.	×	.....	.....
Tellina oregonensis Conr.	×	×	×
Yoldia oregona Shum.	×	.....	.....
GASTEROPODA:			
Alectryon newcombei Mrm.[24a]	×	×	×
Bullia buccinoides Mrm.	×	×	.....
Crepidula prærupta Conr.	×	.....	.....
Eudolium petrosum Conr.	×	.....	.....
Natica oregonensis Conr.	×	×	.....
Patella geometrica Mrm.[24a]	×	×	.....
Polinices callosa Gabb.	×	.....	.....
Polinices galianoi Dall.	×	×	.....
SCAPHOPODA:			
Dentalium conradi Dall.	.....	.....	×

[24a] Species characteristic of this horizon.

Locality 129; sandstone and conglomerate, seacliffs between Muir and Coal Creeks west of Otter Point, Sooke, Vancouver Island. (C. F. Newcombe and H. Hannibal.)

Locality 130; basal sandstone, seacliffs at Fossil Creek, two miles west of Sherringham Point, Jordan River, Vancouver Island. (H. Hannibal.)

Locality 131; basal sandstone, seacliffs one half of a mile east of Slide Hill telegraph station, Jordan River, Vancouver Island. (H. Hannibal.)

THE ASTORIA SERIES.

The name Astoria formation as applied to a stratigraphic division of the Oregon Tertiary was first used in print by Cope[25] who

[25] *Am. Nat.*, XIV., 1880, p. 457.

says "the unpublished notes of Prof. Condon, formerly State Geologist, state that the backbone of the Coast Range consists of argillaceous shales, which contain invertebrate and vertebrate fossils, frequently in concretions. Some of the latter are Physoclostous fishes with strongly ctenoid scales. To this formation, Dr. Condon gives the name of *Astoria Shales.* Above this is an extensive Tertiary deposit rich in Mollusca, which is usually interrupted by the central elevations of the mountain axis. Prof. Condon refers this to an Upper Miocene age under the name of the *Solen* beds."

As in the instance of other Tertiary formations named before the modern exact method of describing a type section or area and basing a formation on it came into use, the definition of the Astoria Shales is vague, and has led to the inclusion under that name of nearly all the Lower Miocene-Oligocene of northwestern Oregon in spite of unconfirmed suspicions on the part of several California geologists that more than one horizon was represented there. Under the circumstances it is desirable to go back and see what Condon intended the name to cover.

At the time of Hannibal's visit in 1911 the sequence of faunas and range of species in the North Pacific Coast Oligocene and Lower Miocene were not understood, and except for keeping the material from the several localities at Astoria separate no attempt was made to work out the stratigraphy and it was not until the excellent sections exposed along both coasts of the Straits of Fuca were carefully collected in during the spring and summer of 1912 that a definite clue to the presence of two formations at Astoria was obtained. A second visit was paid to the section there during that summer, and later, through the courtesy of Prof. Collier, Condon's collection at the University of Oregon was briefly examined with the idea of deciding what Condon intended the "Astoria Shales" and "*Solen* beds" to include.

From the Astoria Shales there is in the Condon collection a quantity of invertebrate material and fish remains[26] largely incased in gray limestone concretions, and derived without doubt from the

[26] See the forms figured in the Atlas Geol. Wilke's Expl. Exp., 1849, Pl. XVI.–XVII.

low westward dipping monocline of ashy shales which extends from above Tongue Point, several miles up the Columbia River, to Smith Point below the city, forming an unbroken bluff back of the town beneath the scattered areas of Pliocene basalt. Most of the distance these shales reach down to the water's edge and quantities of round or kidney shaped gray limestone concretions are washed out of them by the combined action of the tide and river currents. Practically the entire succession of beds in this monocline represent the Seattle horizon and it is probable that this is what Condon intended to be his type section if he had any specific section in mind. However, the collections and description indicate that he also intended to include in the Astoria the San Lorenzo Shales of Clatsop and Columbia counties which conformably underlie the Seattle beds, and make up to a much greater degree the sedimentary portion of the backbone of the Oregon Coast Range.

The "*Solen* beds" evidently comprised three things, the Empire sandstone of the Coos Bay district with *Solen sicarius* Gld., the sandstones with *Solen curtus* Conr. at the foot of 19th Street at Astoria, unconformable on the Astoria Series and from the accompanying fauna evidently Monterey,[27] and the basal San Lorenzo tuffs at Smith's quarry near Eugene with *Solen curtus* Conr. As this last locality is isolated from the main Astoria area and the fauna is quite distinct from that in any of the shales of the Astoria, though the difference is entirely the result of the character of the bottom at the time the beds were laid down, it is not surprising that Condon should have supposed it to represent a horizon nearer to the Monerey locality at Astoria which contains one or two common species.

The writers propose therefore to use the name Astoria Series, not in a loose sense for all the Oligocene-Lower Miocene of western Oregon but as a general name for the conformable sequence of beds here divided on palaeontological evidence into two horizons, the San Lorenzo and Seattle formations. To these are added on the north coast of Washington a third division, soft semicoherent beds everywhere else removed by erosion before the deposition of the Monterey, the Twin River formation.

[27] See list from here in connection with the description of the Monterey formation.

FIG. A.

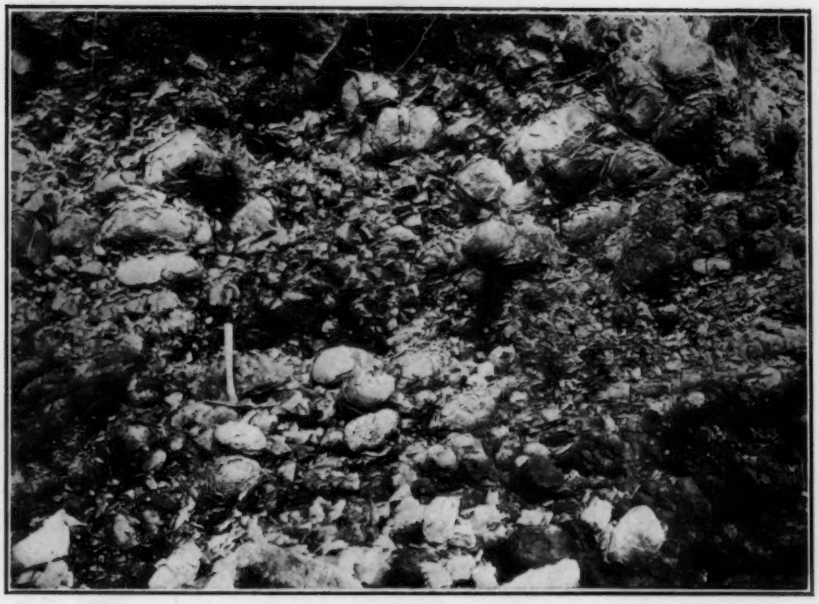

FIG. B.

FIG. A. Tuffaceous San Lorenzo sandstone (Astoria series) at old Smith Quarry, Eugene, Oregon.

FIG. B. Weathered basic tuffs interbedded in San Lorenzo formation (Astoria series) on Vance Creek southwest of Union City, Washington.

Astoria Series
- Twin River formation (zone of *Acila gettysburgensis* Rgn., *Turritella oregonensis* Conr., and *Polinices olympidii* Rgn.).
- Seattle formation (zone of *Acila gettysburgensis* Rgn., *Turcicula washingtoniana* Dall, *Turritella newcombei* Mrm., and *Macrocallista vespertina* Conr.).
- San Lorenzo formation (zone of *Acila shumardi* Dall and *dalli* Arn., *Turritella newcombei* Mrm., *Turcicula columbiana* Dall, and *Macrocallista pittsburgensis* Dall).

The average thickness of the Astoria Series is not less than 12,000 feet, but at some points it attains a much greater development. In the Cape Flattery section about 17,000 feet of apparently conformable coarse sandstones and conglomerates, derived largely from the bedrock series of Vancouver Island, from their fossil contents appear to belong exclusively to the San Lorenzo horizon. The base of the section is cut off by faulting at the mouth of the Soo-es River while the uppermost beds pitch beneath the waters of the Straits of Fuca. Between Winlock and Shoalwater Bay, also in Washington, is a monotonous westward dipping succession of the Astoria Series which if aggregated would total more than 50,000 feet of beds. The paucity of outcrops and the recurrence of certain igneous flows and tuffs associated with the same basal San Lorenzo fauna suggests the presence of a repetition by step faulting which, with the limited time spent in this district of heavy forests, it was impractical to trace out.

The San Lorenzo Formation.

The name San Lorenzo formation has been used by the senior writer[28] for a series of sandstones and diatomaceous shales in the Santa Cruz Mountains, California. Nearly the entire San Lorenzo fauna reappears at a definite horizon in the Tertiary of the North Pacific Coast, *i. e.*, the lowest faunal division of the Astoria Series.

[28] Prof. Pap. 47, U. S. Geol. Sur., 1906, p. 16; Santa Cruz Folio No. 163, U. S. Geol. Sur., 1909; *Proc. U. S. Nat. Mus.*, XXXIV., No. 1617, 1908, p. 348.

It is therefore convenient to use the name San Lorenzo here as well as in California.

On the North Pacific Coast the San Lorenzo ordinarily consists of two members; a basal sandstone and conglomerate varying from 10 to 500 feet or more in thickness and composed largely of worked over volcanic ejectmenta, lying on the basalt or andesite flow which at many points marked the opening of the Astoria epoch, or directly on older rocks; and a shale member several thousand feet thick ordinarily arenaceous, gray and massive, less frequently ashy and dark colored, or calcareous and bluish. Seen under the microscope this shale is composed largely of fine volcanic detritus and has little of the organic character of the San Lorenzo shale of California.

The principal areas of the San Lorenzo formation on Vancouver Island form the narrow intermittent strip of Oligocene sandstones and shales bordering the southwest coast from Sombrio River west to Barkley Sound. In Washington the conglomerates of the Cape Flattery section and eastward to Shroud Head; the sandstones and shales overlying the Oligocene basalts and andesites south and west of Port Townsend; the sandstones overlying the lower Astoria basalts west of Port Orchard Sound and forming the lower half of the Bainbridge Island section of the Seattle Monocline; the shales overlying the basal Astoria basalts north and east of Oakville, Porter, and Elma; the lowest Oligocene exposed in the Lincoln Creek section; and a large part of the monocline previously mentioned as occurring west of Winlock including the Winlock, Pe Ell, Holcomb, Skamokawa and Upper Nasel River exposures are noteworthy. In Oregon the Astoria shales south of the Columbia River at Clatskanie, Scapoose, the upper Nehalem Valley, and West Dairy Creek, isolated exposures about the borders of the Willamette Valley at Silverton, McCoy, and overlying the Eocene basalts at Eugene and Springfield, the lowest beds of the westward dipping monocline between Blodgett and Newport, and the steeply dipping section exposed in the seacliffs south of the entrance to Coos Bay between Basendorfs (Miner's Flat) and Tunnel Point should be regarded as contemporaneous. The so-called Pliocene of the Yahates River belongs also to this horizon.

A typical San Lorenzo fauna has been collected from the area north and east of Porter, Washington.

Partial List of Species in the San Lorenzo Horizon of the Astoria Series (Middle Oligocene) of the Porter-Oakville District, Washington.

	50	51	52	53	54	55	56	109	207
PELECYPODA:									
Cardium lorenzoanum Arn	×	×	×	×	×	...	×	...	...
Crenella porterensis Wvr.	×	...	×	×	×	...	...	...	...
Ervilia oregonensis Dall[29]	...	×	...	...	...	...	...	...	...
Macrocallista mathewsoni Gabb	...	...	...	...	...	...	...	×	...
Macrocallista pittsburgensis Dall[29]	...	...	...	×	...	...	...	...	...
Malletia chehalisensis Arn.[29]	×	...	...	×	...	...	...	...	...
Marcia oregonensis Conr.[30]	×	...	...	...	...	...	...	...	...
Ostrea idriænsis Gabb	...	×	...	...	...	...	...	...	...
Pecten branneri Arn.[29] (*P. proavus* Arn., *P. washburnei* Arn.)	...	×	...	...	...	...	...	×	...
Pecten peckhami Gabb	...	...	×	...	×	×	...	...	×
Semele gayi Arn.[29]	...	×	...	...	...	...	...	...	...
Thracia trapezoidea Conr	...	...	...	×	...	...	...	...	...
Thyasira bisecta Conr.[30]	...	...	...	×	...	...	...	...	...
Yoldia impressa Conr	×	×	...	×	...	...	...	...	×
GASTEROPODA:									
Epitonium rugiferum Dall[29]	...	×	...	...	...	...	...	...	...
Hipponyx carpenteri Arn.[29]	...	×	...	...	...	...	...	...	...
Molopophorus gabbi Dall[29]	...	...	...	...	...	...	...	×	...
Patella mateoensis Arn.[29]	...	×	...	...	...	...	...	...	...
Turcicula columbiana Dall[29]	...	...	...	...	×	...	...	×	...
Priscofusus hecoxi Arn.[29]	×	...	...	×	×	...	×	×	...
Priscofusus sanctæcrucis Arn.[29]	...	×	...	...	...	...	...	...	...
Turritella newcombei Mrm.[29]	×	×	×	×	×	×	×	...	...
SCAPHOPODA:									
Dentalium conradi Dall	×	×	×	×	×	×	×	...	×
CEPHALOPODA:									
Aturia angustata Conr	...	...	...	...	...	...	...	...	×
BRACHIOPODA:									
Terebratalia occidentalis Dall[30]	...	×	...	...	...	...	...	×	...
Terebratulina caputserpentis L.[30]	...	×	...	...	...	...	...	×	...
ECHINODERMATA:									
Cidaris merriami Arn.[29]	...	...	...	...	...	...	...	...	×

NOTE.—*Thracia condoni* Dall, *Acila cordata* Dall, *dalli* Arn. and *shumardi* Dall, *Strepsidura californica* Arn. (*S. oregonensis* Dall), *Epitonium condoni* Dall and *rugiferum* Dall, and *Miopleionia indurata* Conr. are also characteristic species of this horizon.

Locality 50; massive shaly sandstone, road cuts one fourth of a mile southeast of Porter along Chehalis River, Washington. (H. Hannibal.)

[29] Species characteristic of this horizon.

[30] Species still living.

Locality 51; basal marly tuffs, bluffs at old logdam on Porter Creek one and one half miles above Porter, Washington. (H. Hannibal.)

Locality 52; massive shaly sandstone, bluffs one fourth of a mile below logdam on Porter Creek, Porter, Washington. (H. Hannibal.)

Locality 53; massive shaly sandstone, bluff on Chehalis River below Porter, Washington. (H. Hannibal.)

Locality 54; massive shaly sandstone, bluffs along Porter Creek three fourths of a mile above Porter, Washington. (H. Hannibal.)

Locality 55; massive shaly sandstone, cut on Lytle logging R. R. near top of ridge one mile above switch, Porter, Washington. (H. Hannibal.)

Locality 56; massive shaly sandstone, bluffs along Porter Creek one mile above old logdam, Porter, Washington. (H. Hannibal.)

Locality 109; basal tuffaceous conglomerate, beds immediately overlying basalt at quarry on N. P. R. R., one mile west of Oakville, Washington. (H. Hannibal.)

Locality 207; tuffaceous shale, bluffs along Vances Creek two and one half miles above junction with Skokomish River and thirteen miles above Union City, Washington. (Thos. Purdy, Ed. McCreavy, and H. Hannibal.)

The Seattle Formation.

In the sections at Gettysburg, Bainbridge Island, Lincoln Creek, Nasel River, Nehalem River, Yaquina River, and several other points the San Lorenzo formation is overlain conformably by a succession of beds usually finer grained, thinner bedded, and more calcareous, though the exceptions are too numerous to mention, containing a rather different fauna of less distinctly tropical type and a forerunner of the boreal Twin River fauna which succeeded it. The most fossiliferous exposures of this formation are in the upper beds of the northward dipping Seattle monocline extending from Restoration Point on Bainbridge Island across Admiralty inlet to Alki Point, Georgetown, and Columbia City in Seattle and reappearing east of Lake Washington near the mouth of Coal Creek below Newcastle. The maximum thickness is exposed on Bainbridge Island and aggregates perhaps 3,000 or 4,000 feet of beds.

Other exposures are to be found in Washington on the north coast east of Gettysburg and at the mouth of the Sekiu River, in the uppermost Oligocene beds of the Lincoln Creek section, the beds unconformable beneath the Monterey sandstone south of Elma on Delazine Creek, the lower Nasel River and Ilwaco Sections, and the bluffs at Grays River. In Oregon the Astoria Section, the beds at Nehalem Harbor, and those about the head of Yaquina Bay are contemporaneous.

FIG. A.

FIG. B.

FIG. A. Riprap beach formed from thin sandstone beds intercalated with Seattle shales at mouth of Sekiu River, north coast of Washington.

FIG. B. Massive tuffaceous San Lorenzo shales (Astoria series) on Chehalis River at Lincoln Creek, Washington.

The following fauna was obtained from the Seattle Monocline and at Astoria.

Partial List of Species in the Seattle Horizon of the Astoria Series (Middle Oligocene) of Seattle District, Washington and at Astoria, Oregon.

	Oregon			Washington				
	46	47	273	48	49	103	206	261
PELECYPODA:								
Acila gettysburgensis Rgn.[31]	...	...	×	×	×	×	...	×
Cardium lorenzoanum Arn	...	...	...	×	...	×	...	...
Crenella porterensis Wvr.[31]	...	...	...	×	...	×	×	...
Limopsis nitens Conr.[31]	×	...	...	...	...	...	...	...
Macrocallista vespertina Conr.[31]	...	...	...	...	...	×	×	×
Marcia oregonensis Conr.[32]	...	...	...	×	×	×	...	×
Modiolus ynezianus Arn.	...	...	...	×	...	×	...	...
Mytilus sammamishensis Wvr	...	...	...	...	...	...	×	...
Nucula townsendi Dall	...	...	...	...	...	×	...	...
Panope generosa Gld.[32]	...	...	...	...	...	...	×	×
Pecten peckhami Gabb	...	×	×	...	×	...	...	...
Pecten waylandi Arn.[31]	×	×	×	...	...	...	...	...
Phacoides acutilineatus Conr	...	...	...	×	×	×	×	...
Solemya ventricosa Conr.[31]	...	...	...	...	...	×	...	...
Solen curtus Conr	...	...	×	...	...	×	×	×
Spisula albaria Conr	...	...	...	...	...	...	×	...
Tellina lorenzoensis Arn. (*Macoma moliniana* Dall)[31]	...	...	...	×	×	×	×	...
Tellina obruta Conr	...	...	...	×	...	×	...	...
Tellina oregonensis Conr	...	...	...	×	...	...	×	×
Thracia trapezoidea Conr	...	...	...	...	...	×	...	...
Thyasira bisecta Conr.[32]	...	...	...	×	...	×	...	...
Venericardia castor Dall[31]	...	...	...	...	...	×	×	×
Yoldia impressa Conr	...	...	...	×	...	×	×	×
Yoldia oregona Shum	...	...	...	...	...	...	×	...
GASTEROPODA:								
Crepidula prærupta Conr	...	...	...	...	...	×	×	×
Eudolium petrosum Conr	...	...	...	×	×	×	...	...
Miopleionia indurata Conr.[31]	×	...	...	...	...	×	...	...
Natica oregonensis Conr	...	...	...	×	×	×	...	...
Turcicula washingtoniana Dall[31]	...	...	×	×	×	×	...	...
Turritella newcombei Mrm.[31]	...	...	...	...	...	×	×	...
SCAPHOPODA:								
Dentalium conradi Dall	...	...	...	×	...	×	×	×
CEPHALOPODA:								
Aturia angustata Conr	...	...	×	×	...	×	...	...
BRACHIOPODA:								
Hemithyris astoriana Dall[31]	×	...	...	...	...	...	...	...

Locality 46; ashy shales with limestone nodules, beach at foot of 46th Street, Astoria, Oregon. (H. Hannibal.)

[31] Species characteristic of this horizon.

[32] Species still living.

Locality 47; ashy shales with limestone nodules, beach between foot of Hull Street and Smith Point, Astoria, Oregon. (H. Hannibal.)

Locality 273; ashy shale, bluff back of town between 1st and 13th Streets, Astoria, Oregon. (H. Hannibal.)

Locality 48; sandy shale, beach from Alki Point south one fourth of a mile along shore of Puget Sound, Seattle, Washington. (H. Hannibal.)

Locality 49; massive shale, railroad cuts between Argo and Georgetown Stations, Seattle, Washington. (H. Hannibal.)

Locality 103; shaly sandstone, beach between south side of entrance to Blakely Harbor and Restoration Point, Bainbridge Island, Washington. (H. Hannibal.)

Locality 206; sandstone, bluffs overlooking Andrews Bay, Lake Washington, three fourths of a mile east of Columbia City Station, Seattle, Washington. (H. Hannibal.)

Locality 261; sandstone, bluffs along Coal Creek three fourths of a mile above Lake Washington, Newcastle, Washington. (H. Hannibal.)

Twin River Formation.

Conformable above the Seattle beds in the section of the Astoria series between Port Crescent and Pysht River on the north coast

Partial List of Species in the Twin River Horizon of the Astoria Series (Middle Oligocene) of the North Coast of Washington.

	120	121	122	158	159
PELECYPODA:					
Acila gettysburgensis Rgn.[33]	×	×	×	.....	×
Cardium lorenzoanum Arn	×	.....	×	.....	.....
Marcia oregonensis Conr. (*M. subdiaphana* Cpr.)[34]	×	.....	.....	.....	.....
Modiolus ynezianus Arn	.....	.....	×	.....	.....
Mytilus sammamishensis Wvr	×	.....	.....	.....	.....
Pecten peckhami Gabb	.....	.....	.....	.....	×
Phacoides acutilineatus Conr	×	.....	×	.....	.....
Solen curtus Conr	×	.....	.....	.....	.....
Tellina obruta Conr	×	×	×	.....	×
Thracia trapezoidea Conr	×	.....	.....	.....	.....
Thyasira bisecta Conr.[34]	×	×	×	.....	.....
GASTEROPODA:					
Eudolium petrosum Conr	×	.....	×	.....	×
Natica oregonensis Conr	×	.....	×	.....	×
Polinices galianoi Dall	.....	.....	.....	×	.....
Polinices olympidii Rgn.[33]	×	.....	×	.....	.....
Sinum scopulosum Conr	×	.....	.....	.....	.....
Turritella oregonensis Conr.[33]	×	.....	×	.....	.....
SCAPHOPODA:					
Dentalium conradi Dall	×	.....	×	.....	×
CEPHALOPODA:					
Aturia angustata Conr	×	.....	.....	.....	×

[33] Species characteristic of this horizon.

[34] Species still living.

Locality 120; clay shales, seacliffs west of Twin for a distance of three fourths of a mile along shore, Olympic Peninsula, Washington. (A. B. Reagan, H. Hannibal.)

Locality 121; clay shales and sandstone, seacliffs at Arc Reef Point two and one half miles west of Twin, Washington. (H. Hannibal.)

Locality 122; shaly sandstone, seacliffs one half to three miles east of Twin, Washington. (A. B. Reagan, H. Hannibal.)

Locality 158; sandstone and shale, seacliffs at small point west one mile from Deep Creek, Twin, Washington. (H. Hannibal.)

Locality 159; shale and sandstone, seacliffs one and one half miles east of Pillar Point, Twin, Washington. (H. Hannibal.)

of Washington and extending from about three miles east of Twin River west nearly to Pysht Bay where it is faulted against the Monterey, is a stretch of soft clay-shales perhaps 2,000 feet thick intercalated with occasional thin beds of sandstone that wash out on the beach as flags. These beds, both shales and sandstone, contain a fauna of a marked boreal type. Most of the species are undescribed, but the few already known indicate that it is quite as closely allied to the Vaqueros and Monterey as to the San Lorenzo and Seattle faunas, yet sufficiently distinct from all of these.

The horizon is named from the locality where the best fossil collecting was obtained.

The Monterey Formation (Oligocene-Miocene).

The term "Monterey Shales" has long been current in the geological literature of California for the great series of diatomaceous shales first described by Blake[35] and Lawson[36] from Monterey in that state. While these deposits are particularly interesting to the oil geologist on account of their petroliferous character, their affinities have long been uncertain owing to the impoverished molluscan fauna. Dr. J. P. Smith[37] was probably the first writer to correctly interpret their relations, considering them as simply an off-shore facies of the beds variously called the Upper Vaqueros, Temblor, *Agasoma* zone, and *Turritella ocoyana* beds. Recently the junior writer visited the type section and had no difficulty in securing a

[35] Blake, W. P., *Proc. Phila. Acad. Nat. Sci.*, VII., 1855, p. 328–331.

[36] Lawson, A. C., *Bull. Geol. Univ. Cal.*, I., 1893, p. 22.

[37] *Proc. Cal. Acad. Sci.* (4th Ser.), III., 1912, p. 161–182.

small but characteristic fauna from limestone lenses intercalated in the diatomaceous shales.

Partial List of Species in the Monterey Formation (Oligocene-Miocene) Between Monterey and Carmel, California.

PELECYPODA:

Arca devincta Conr. (*A. montereyana* Osmont).[38]
Leda taphria Dall.[39]
Leda penita Conr.[38]
Marcia congesta Conr. (*Tellina congesta* Conr.).[38]
Nucula townsendi Dall (ranges into Astoria).
Pecten peckhami Gabb (ranges into Tejon).
Venericardia montereyana Arn.[38]

GASTEROPODA:

Caesia arnoldi F. M. And. (ranges into Empire).
Ficus kernianus Cooper.[38]
Polinices saxea Conr.[38]
Turritella cf. variata Conr.[38]

This unmistakably fixes the identity of the *Agasoma* zone of California and what the senior writer[40] has described from the north coast of Washington as the Clallam formation with the Monterey shale, and it is proposed to unite all these under this prior name. It should be specifically understood however that another formation in California, the Lower Vaqueros, *i. e.*, the zone of the beds in the Las Vaqueros Valley, to which the name Vaqueros was applied by Hamlin[41] and from which were obtained such species as *Mytilus expansus* Arn., *Ostrea* cf. *Tayloriana* Gabb, *Ostrea* cf. *Titan* Conr., *Pecten magnolia* Conr., and *Turritella inezana* Conr., are not included in the Monterey. This formation lies unconformably below the Monterey in the Santa Monica Mountains, in the Santa Clara River Valley (where it is more particularly characterized by *Scutella fairbanksi* Arn.), and in the Santa Cruz Mountains. For it the name Vaqueros is retained.

Perhaps the only objection to the use of the term "Monterey Formation," and certainly not an important one from a palæonto-

[38] Species characteristic of this horizon.
[39] Species still living.
[40] *Bull. Geol. Soc. Am.*, XVIII., 1906, p. 461.
[41] Water Supply Paper 89, U. S. Geol. Sur., 1904, p. 14.

FIG. A.

FIG. B.

FIG. A. Landsliding in soft clayshales of Monterey formation on O. W. Milwaukee Railway between Cosmopolis and North River, Washington.

FIG. B. Jump-off-Joe rock and Cape Foulweather light-house, Newport, Oregon. The rocks in the foreground are Monterey sandstones and shales, in the distance basalts intruded in the Monterey.

logical standpoint, is total absence on the North Pacific Coast of any beds in this formation, or in any other formation for that matter, lithologically similar to the diatomaceous shales so prevalent in Monterey of California. This became vital, however, from the point of view of the economic geologist since upon the presence of such shales or similar organic deposits equally lacking here, depends the possibilities of the discovery of petroleum in commercial quantities. Except for coal near Clallam Bay, Washington,[42] and on the North Nehalem River in Oregon[43] no organic products of economic value are known in this formation.

The Monterey formation of this region ordinarily consists of two members; the lower a massive buff sandstone often containing thin lignite seams and attaining south of the Chehalis River a thickness of perhaps 1,500 feet; the upper fine soft clay shales perhaps 2,500 feet thick in the same section which is one of the most complete.

To this formation are referred the conglomerates overlying the San Lorenzo shales at Carmanah Point on Vancouver Island; and in Washington: the Clallam section and the conglomerates unconformable on the Seattle beds between West Clallam and the Hoko River; a small area of Tertiary sandstone faulted into the so-called Cretaceous north of the Hoh River; an area of shales faulted against the Empire formation on the upper Wishkah River; the westward dipping monoclinal section from a few miles west of Elma to North River Junction on the south side of the Chehalis River and equivalent strata south to the Willipa River; and an isolated area beneath the Pliocene basalt on Elocheman River about twelve miles above the Columbia. In Oregon isolated areas lying on the Astoria series or exposed beneath the Pliocene basalt at Mountain Dale, Westport, the foot of 19th Street at Astoria, and the south shore of Tillamook Harbor are of this age as well as a narrow belt of rocks faulted against the Astoria series and extending for several miles up and down the coast west of Newport.

The following species were obtained in the Clallam section and at Astoria.

[42] R. Arnold, Bull. 260, U. S. Geol. Sur., 1905, p. 413–427.
[43] J. S. Diller, 17th Ann. Rept. U. S. Geol. Sur., Pt. I., 1896, p. 494.

Partial List of Species in the Monterey Formation (Oligocene-Miocene) of the Clallam Bay District, Washington, and at Astoria, Oregon.

	45	89	160	161	162	163
PELECYPODA:						
Acila conradi Meek	×	×	...	...	...	×
Arca devincta Conr. (*A. montereyana* Osmont)[44]	×	×	×	×	×	×
Arca trilineata Conr	...	×	...	...	...	...
Diplodonta parilis Conr	×	...	...	...	...	...
Dosinia whitneyi Gabb[44]	...	...	×	×	...	...
Leda penita Conr.[44]	×	×	...	...	...	...
Macoma piercei Arn.[44]	...	...	...	×	...	...
Marcia oregonensis Conr. (*M. subdiaphana* Cpr.)[45]	×	×	...	×	...	×
Modiolus rectus Conr. (*M. directus* Dall)[45]	×	...	...	×	...	...
Panope generosa Gld.[45]	×	×	...	×	...	×
Pecten fucanus Dall[44]	...	×	...	×	...	×
Pecten propatulus Conr.[44]	×	×	×	...	...	...
Phacoides acutilineatus Conr	×	...	...	×	...	×
Solen curtus Conr	×	×	...	×	...	...
Spisula albaria Conr	×	×	...	×	...	×
Spisula catilliformis Conr.[45]	...	×	...	...	...	...
Tellina arctata Conr.[44]	×	×	...	×	...	×
Tellina nuculana Dall[44]	×	...	...	...	...	...
Tellina obruta Conr. (*T. albaria* Conr.)	×	...	...	×	...	×
Tellina oregonensis Conr	×	×	...	...	...	×
Thracia trapezoidea Conr	×	×	...	×	...	×
Thyasira bisecta Conr.[45]	×	...	...	×	...	...
Venericardia subtenta Conr. (*V. quadrata* Dall)[44]	...	...	...	×	...	×
Venus clallamensis Rgn. (*V. ensifera* Dall)[44]	×	×	...	×	...	...
Venus olympidea Rgn.[44]	...	×	...	...	...	...
Yoldia impressa Conr	×	...	...	...	...	...
Yoldia oregona Shum	×	...	...	...	...	...
GASTEROPODA:						
Ampullina oregonensis Dall	×	...	...	...	...	...
Cæsia arnoldi F. M. And.	×	...	...	×	...	...
Chrysodomus nodiferus Conr. (*Fusus stanfordensis* Arn.)	×	×	...	×	...	...
Crepidula prærupta Conr.	×	×	...	×	...	...
Cylichnella petrosa Conr.[44]	×	...	...	...	...	...
Ficus stanfordensis Arn	...	×	...	...	...	...
Fusinus corpulentus Conr. (*F. medialis* Conr.)[44]	×	...	...	...	...	...
Fusinus devinctus Conr.[44]	×	...	...	...	...	...
Natica oregonensis Conr	×	...	...	×	...	...
Polinices saxea Conr.[44]	...	×	...	×	...	...
Priscofusus geniculus Conr.[44]	×	...	...	×	...	×
Sinum scopulosum Conr	×	×	...	...	...	...
Turris wynoocheensis Wvr.[44]	...	...	...	...	...	×
Turritella oregonensis Conr.[44]	×	...	...	...	...	...
SCAPHOPODA:						
Dentalium conradi Dall (*D. petricola* Dall)	×	×	...	×	...	×
CEPHALOPODA:						
Aturia angustata Conr	...	...	...	...	...	×

Locality 45; basal sandstone, beach at foot of 19th Street, Astoria, Oregon. (H. Hannibal.)

[44] Species characteristic of this horizon.

[45] Species still living.

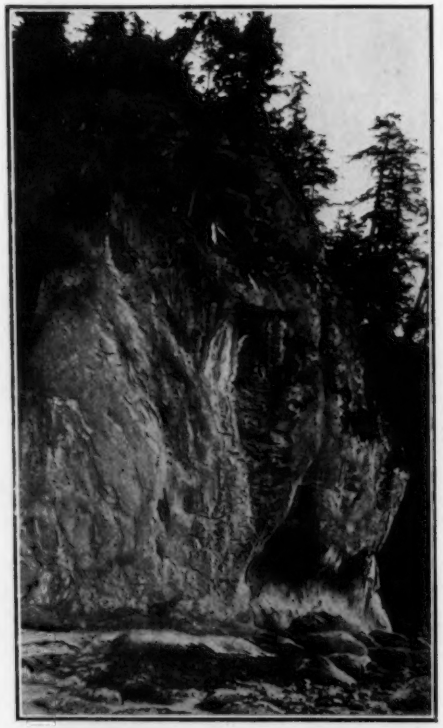

FIG. A.

FIG. B.

FIG. A. Monterey sandstone at Pillar Point near Clallam Bay, Washington.
FIG. B. Sandstone dyke in tuffaceous Empire shales on upper reaches of Wishkah River, Aberdeen, Washington.

Locality 89; basal sandstone and conglomerate, seacliffs eastward from Slip Point for half a mile along shore, Clallam Bay, Washington. (A. B. Reagan, H. Hannibal.)

Locality 160; massive sandstone, seacliffs at Pillar Point near Clallam Bay, Washington. (H. Hannibal.)

Locality 161; shaly sandstone, seacliffs one and one half miles west of Pillar Point near Clallam Bay, Washington. (H. Hannibal.)

Locality 162; carbonaceous sandstone, seacliffs at Clallam coal mine near Clallam Bay, Washington. (H. Hannibal.)

Locality 163; shaly sandstone, seacliffs one and one half miles west of Clallam coal mine near Clallam Bay, Washington. (H. Hannibal.)

The Empire Formation (Miocene).

To beds exposed on the east shore of Coos Bay south of Empire, Oregon, Diller[46] has given the name Empire formation. This horizon the junior writer found in his field work to be widespread in Western Oregon and Washington. In many respects the Empire fauna is peculiar since it evidently represents the oldest distinctly Miocene strata on the Pacific Coast. For, while the fauna is perhaps most closely allied to the *Scutella breweriana-S. gabbi* beds of the San Pablo formation of the San Francisco Bay region in California, the larger proportion of recent species in those deposits and rather marked faunal differences preclude an exact correlation.

In the Empire district about 500 feet of beds, sandstones at the base grading upward into massive shales partially organic in character, but more or less derived from worked over volcanic debris, represent the formation. At Cape Blanco sandstones alternating with compact bedded volcanic ash containing abundant plant remains attain about the same thickness. In the area between Willipa Harbor and Grays Harbor in Washington the base of the formation is represented, being marked by a zone of basalt tuffs and breccias. The most important area, however, lies between the Chehalis Valley and the foot of the Olympic Mountains, where the formation attains a thickness of perhaps 4,000 feet, chiefly sandstones at the base grading upward into massive tuffaceous shales with some intercalated sandstones. Small Empire areas occur on the west coast of the Olympic Peninsula between Cape Grenville and

[46] 17th Ann. Rept. U. S. Geol. Sur., Pt. I., 1896, p. 475.

Partial List of Species in the Empire Formation (Middle Miocene) of the Coos Bay-Cape Blanco District, Southwestern Oregon.

	23	26	31	36	37	39	43	44
PELECYPODA:								
Acila conradi Meek		×			×			
Arca trilineata Conr		×			×			
Cardium coosense Dall[48]				×				
Cardium meekianum Gabb		×		×	×			
Diplodonta parilis Conr		×			×			
Glycymeris grewingki Dall[48] (*G. gabbi* Dall, *G. conradi* Dall)		×			×			×
Macoma astori Dall[48]					×			×
Macoma calcarea Gmel.[49]		×		×			×	
Macoma inquinata Desh.[49]							×	
Marcia oregonensis Conr. (*M. subdiaphana* Cpr.)[49]		×		×			×	×
Modiolus rectus Conr. (*M. directus* Dall)[49]					×			
Mulinia densata Conr. (*M. oregonensis* Dall)					×			
Mya truncata L.[49]				×				
Mytilus middendorffi Grnk. (*M. condoni* Dall)[48]	×	×						
Panomya ampla Dall (*P. chrysis* Dall)[49]							×	
Parapholas californica Conr.[49]							×	
Paphia stayleyi Gabb				×			×	
Pecten coosensis Shum[48]				×		×		
Phacoides acutilineatus Conr					×			
Schizothærus pajaroanus Conr					×			
Siliqua nuttalli Conr. (*S. oregonia* Dall)[49]		×						
Solen sicarius Gld. (*S. conradi* Dall)[49]		×		×	×		×	×
Spisula albaria Conr. (*S. præcursor* Dall)		×		×	×	×	×	×
Tellina aragonia Dall[48]		×			×			
Thracia trapezoidea Conr				×				
Venus securis Shum. (*V. parapodema* Dall)		×			×			
Yoldia impressa Conr				×				
Yoldia oregona Shum					×			
Yoldia strigata Dall				×				
GASTEROPODA:								
Ampullina oregonensis Dall				×				
Argobuccinum cammani Dall[48]				×				×
Argobuccinum coosense Dall[48]							×	
Bathytoma gabbiana Dall[48]				×				
Boreotrophon stuarti Smith[49]				×			×	
Bullia bogachiclia Rgn.[48]		×						
Cæsia arnoldi F. M. And.		×			×			
Calliostoma cammani Dall[48]				×				
Calyptræa inornata Gabb				×	×			
Cancellaria oregonensis Dall[48]		×						
Chrysodomus bairdi Dall[48]				×				
Chrysodomus imperialis Dall				×				
Chrysodomus nodiferus Conr. (*Fusus stanfordensis* Arn.)		×						
Crepidula adunca Sby.[49]		×						
Crepidula princeps Conr					×			×
Cymatium pacificum Dall[48]		×		×				
Fusinus coosensis Dall[48]		×		×				×
Miopleionia oregonensis Dall					×			×
Natica clausa B. & S. (*N. consors* Dall)[49]	×	×		×	×		×	×

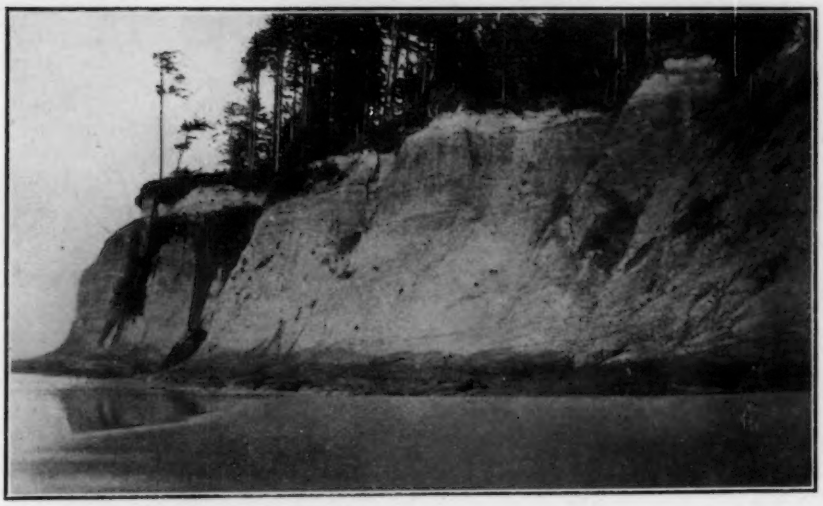

FIG. A.

FIG. B.

FIG. A. West face of Coos Head, Coos Bay, Oregon. Empire sandstone overlain by Pleistocene sands.

FIG. B. Pliocene basalts associated with river sands and gravel on Portland-Tacoma Railway below Little Falls, Washington.

	23	26	31	36	37	39	43	44
GASTEROPODA:								
Nucella decemcostata Midd. (*Thais præcursor* Dall)[49]	×	×	...	×	...	...	...	×
Nucella lamellosa Gmel. (*Purpura crispata* Chem.)[49]	...	...	...	...	...	...	...	×
Olivella biplicata Sby.[49]	...	×	...	...	...	...	...	...
Olivella pedroana Conr.[49]	...	...	...	×	...	...	...	...
Phalium æquisulcatum Dall[48]	...	...	...	×	...	...	...	...
Phalium turricula Dall[48]	...	...	...	×	...	...	...	...
Polinices galianoi Dall	...	...	...	×	...	...	...	...
Tegula stantoni Dall[48]	...	...	...	×	...	...	...	...
Turris coli Dall[48]	...	...	...	...	...	...	×	...
Turris impecunia Dall[48]	...	×	...	×	...	...	...	...
Turris perversa Gabb[49]	...	...	...	×	...	...	...	...
Sinum scopulosum Conr	...	...	...	...	...	...	...	×
SCAPHOPODA:								
Dentalium rectius Cpr.[49]	...	...	...	×	...	...	...	...
BRACHIOPODA:								
Discinisca oregonensis Dall	...	...	...	...	...	...	×	...
Terebratalia occidentalis Dall[49]	...	...	...	...	...	...	×	...
ECHINODERMATA:								
Scutella gabbi Rem.[48]	...	×	...	...	×	...	...	...
PISCES:								
Isurus planus Ag	...	...	×	...	...	...	...	...

Locality 23; basal sandstone, seacliffs between Blacklock Point and Floras Lake, Cape Blanco, Oregon. (H. Hannibal.)

Locality 26; basal sandstone, seacliffs southeast of lighthouse for a mile along shore, Cape Blanco, Oregon. (F. F. Wood, H. Hannibal.)

Locality 31; massive shale, beach one fourth of a mile north of South Slough bridge, east shore of Coos Bay, Oregon. (H. Hannibal.)

Locality 36; shaly sandstone, beach between submerged jetty and Fossil Rock, three miles south of Empire, Coos Bay, Oregon. (H. Hannibal.)

Locality 37; basal sandstone, beach for a mile toward Empire from Tarheel Point, Coos Bay, Oregon. (H. Hannibal.)

Locality 39; shaly sandstone, north face of Coos Head, Coos Bay, Oregon. (H. Hannibal.)

Locality 43; basal sandstone, seacliffs between Astoria-Empire unconformity and Goldwashers Gully, coast west of Coos Bay, Oregon. (H. Hannibal.)

Locality 44; basal sandstone, seacliffs between Goldwashers Gully and Coos Head, coast west of Coos Bay, Oregon. (H. Hannibal.)

the mouth of the Quinaielt River, between Cape Elizabeth and Raft River, at the mouth of Raft River, and on the Bogochiel River above

[48] Species characteristic of this horizon.

[49] Species still living.

Mora. The Tertiary rocks of Tchow-un Point,[49a] Queen Charlotte Islands, represent the same horizon.

The following fauna was obtained at Cape Blanco and Coos Bay, Oregon.

THE MERCED FORMATION (MIOCENE-PLIOCENE).

In terming the latest Miocene or earliest Pliocene deposits of the North Pacific Coast the Merced Formation, the writers recognize the contemporaneity of the Scotia section of Eel River Valley, California, the Coos Conglomerate of Coos Bay, Oregon, and the Miocene-Pliocene portion of the Quinaielt formation near Taholah, Washington, with the Miocene-Pliocene beds of the Seven-mile section and exposures on Twelve-mile Creek south of San Francisco, California.

As originally constituted by Lawson[50] the Merced formation apparently included two members, the one in question, steeply tilting beds extending in the Seven-mile Beach section from Mussel Rock northward to the highest *Scutella* bed, the other nearly horizontal sands and clays west of Colma containing a small fauna composed entirely of living species. Subsequently Ashley[51] utilized the name Merced for the older portion, pointing out that the upper beds should be considered separately. Recent collections made by the junior writer show conclusively that the upper horizontal beds are Quaternary and, though the contact is obscure, water-worn pebbles containing *Scutella interlinerta* Stimp. present in them indicate an unconformity with the underlying Miocene-Pliocene.

Partial List of Species in the Merced Formation (Miocene-Pliocene) of the San Francisco Peninsula and Eel River Valley, California.

PELECYPODA:

Arca trilineata Conr., *S.*
Cardium meekianum Gabb, *S, E.*
Diplodonta orbella Gld., *S.*[52]
Glycymeris coalingensis Arn., *E.*[53]
Macoma calcarea Gmel., *E.*[52]

[49a] Dawson, G. M., Rept. Geol. Sur. Can., 1788–9 (1880), p. 87*B*, calls this Skonum Point. Dr. C. F. Newcombe informs the writer that Tchow-un is more correct.

[50] Bull. Dept. Geol. Univ. Cal., I., 1894, p. 115–160.

[51] *Jour. Geol.*, III., 1895, p. 441–6.

Macoma nasuta Conr., *S.*[52]
Marcia oregonensis Conr. (*M. subdiaphana* Cpr.), *S, E.*[52]
Mulinia densata Conr., *S, E.*
Panomya ampla Dall (*P. chrysis* Dall), *E.*[52]
Paphia staleyi Gabb, *S, E.*
Paphia tenerrima Conr., *S.*[52]
Pecten caurinus Gld., *S, E.*[52]
Pecten dilleri Dall, *E.*[53]
Pecten healeyi Arn., *S.*[53]
Pecten nutteri Arn., *S.*
Psephidia lordi Baird, *S, E.*[52]
Schizothaerus nuttalli Conr., *S.*[52]
Schizothaerus pajaroanus Conr., *E.*
Siliqua nuttalli Conr., *S, E.*[52]
Solen sicarius Gld., *S.*[52]
Spisula voyi Gabb (*S. alaskana* Dall), *S, E.*[52]
Tellina buttoni Dall, *S.*[52]
Thracia trapezoidea Conr., *E.*
Venus securis Shum., *S.*

GASTEROPODA:

Caesia mendica Gld., *S.*[52]
Chrysodomus stantoni Arn., *S.*[53]
Chrysodomus tabulatus Baird, *S, E.*[52]
Columbella gausapata Gld. (*Astyris richthofeni* Gabb), *S, E.*[53]
Crepidula onyx Sby., *S.*[52]
Crepidula princeps Conr., *S.*
Natica clausa B. & S., *S, E.*[52]
Nucella decemcostata Midd. (*Purpura lima* auct.), *S.*[53]
Nucella lamellosa Gmel., *S, E.*[53]
Nucella saxicola Val., *S.*[52]
Olivella biplicata Sby., *S.*[52]
Polinices galianoi Dall, *S.*
Stylidium eschrichti Midd. (*Bittium filosum* Gld.), *S.*[53]

SCAPHOPODA:

Dentalium rectius Cpr., *E.*[52]

ECHINODERMATA:

Echinarachnius gibbsi Rem., *S.*[53]
Scutella interlineata Stimp., *S.*[53]
Scutella oregonensis Clark, *S, E.*

S—San Francisco Peninsula. *E*—Eel River Valley.

NOTE.—This and succeeding lists from the Merced and Elk River formations should not be used as a basis for determining percentages of species living or extinct. It has not been convenient to identify all the living species in time to include them on the lists, and in addition a number of undescribed extinct forms occur.

[52] Species still living.
[53] Species characteristic of this horizon

The Merced areas on the North Pacific Coast are, without exception, small and isolated. Deposits limited to the basal conglomerates attain in Oregon a thickness of a few feet at two points on the east shore of Coos Bay south of Empire, and again at the point south of Five-mile Creek on the coast near Bandon.

Partial List of Species in the Merced Formation (Miocene-Pliocene) of the Coast of Oregon and Washington.

	Oregon			Washington		
	34	35	98	77	79	80
PELECYPODA:						
Cardium meekianum Gabb	...	...	...	×	...	...
Macoma calcarea Gmel.[54]	...	...	...	×	...	...
Macoma nasuta Conr	×	...	...	...	...	...
Marcia oregonensis Conr. (*M. subdiaphana* Cpr.)[54]	...	...	...	×	...	...
Mulinia densata Conr. (*M. oregonensis* Dall)	×	...	...	...	...	...
Mytilus edulis L.[54]	...	...	...	...	...	×
Ostrea cf. lurida Cpr.[54]	...	...	×	...	...	...
Panope generosa Conr.[54]	...	...	...	...	...	×
Pecten caurinus Gld.[54]	×	...	...	...	...	...
Pecten dilleri Dall[55]	...	...	...	...	×	...
Phacoides annulatus Rve.[54]	...	...	...	×	...	...
Pholadidea penita Conr.[54]	×	...	...	...	...	...
Psephidia lordi Bd.[54]	...	...	×	...	...	...
Solen sicarius Gld.[54]	...	...	...	×	...	...
Spisula albaria Conr	...	...	...	×	...	×
Spisula voyi Gabb (*S. alaskana* Dall)[54]	...	...	×	...	...	...
Thyasira bisecta Conr.[54]	...	...	...	...	×	...
Venus securis Shum	...	...	...	×	...	...
GASTEROPODA:						
Argobuccinum oregonense Redf.[54]	×	...	...	...	...	...
Astræa inequalis Mart.[54]	×	...	...	...	...	...
Cæsia mendica Gld.[54]	...	...	...	×	...	...
Chrysodomus imperialis Dall	×	...	...	×	...	...
Chrysodomus tabulatus Bd.[54]	...	×	...	...	...	...
Gyrineum marshalli Rgn. (*G. mediocre* Dall)	...	...	...	×	...	...
Littorina remondi Gabb (*L. petricola* Dall)	×	×	...	...	...	...
Natica clausa B. & S.[54]	...	...	...	×	×	...
Nucella decemcostata Midd.[54]	...	×	...	×	...	...
Olivella pedroana Conr.[54]	×	×	...	...	...	...
Purpura foliata Mart.[54]	×	...	...	...	...	...
Stylidium eschrichti Midd. (*Bittium filosum* Gld.)[54]	×	...	...	...	...	...
Tritonalia lurida Midd.[54]	...	...	...	×	...	...
Turcica caffea Gabb[54]	...	...	...	×	...	...
Turris perversa Gabb[54]	...	×	...	×	...	...

Locality 34; basal conglomerate and sandstone, Fossil Rock, three and one half miles south of Empire, Coos Bay, Oregon. (H. Hannibal.)

[54] Species still living.

[55] Species characteristic of this horizon.

Locality 35; basal conglomerate, point south of Fossil Rock, four miles south of Empire, Coos Bay, Oregon. (H. Hannibal.)

Locality 98; basal conglomerate, seacliffs at point three fourths of a mile south of Five Mile Creek, Bandon, Oregon. (H. Hannibal.)

Locality 77; sandstone, seacliffs from Cape Grenville northward for a mile to long landslide, Taholah, Washington. (H. Hannibal.)

Locality 79; shaly sandstone, seacliffs north of Quinaielt River bar, Taholah, Washington. (H. Hannibal.)

Locality 80; sandstone, seacliffs from Cape Elizabeth northward for three fourths of a mile to big landslide, Taholah, Washington. (H. Hannibal.)

Two areas of soft semicoherent sandstone faulted into the Older Tertiary and Mesozoic rocks on the coast of the Olympic Peninsula near Taholah, Washington, contain a fauna evidently the same age. The thickness here is perhaps 500 feet.

The Elk River Formation (Upper Pliocene).

Extending from the Goldwashers' cabin one and three fourths miles southeast of Cape Blanco south to Garrison Lagoon near Port Orford, Oregon, is a gently southward dipping cliff, essentially a raised beach composed of sands and littoral gravels, blue and more or less concretionized at the base but rusty and hardly consolidated above, perhaps 250 feet thick near their contact with the Empire sandstone lying to the north but gradually dropping down below sea level to the south. This formation has been named by Diller[56] the Elk River beds from an important stream which cuts through the section. As a matter of fact Diller's name was given only to the upper rusty portion of the section while the blue beds conformable below were included with the Empire (Cape Blaco Beds) a procedure not borne out by the character of the fauna. It might be added that there is a marked discrepancy between the dip and strike of the Empire beds and the overlying blue sands where the two formations meet that was apparently overlooked by Diller.

The fauna of the Elk River beds consists chiefly of recent species but associated with them are others common to the Merced, thus establishing the Pliocene age of the formation. In a general way this fauna suggests the Deadman Island or Santa Barbara Pliocene in the boreal facies of the fauna and the small percentage of extinct

[56] Bull. 196, U. S. Geol. Sur., 1902, p. 31.

forms, though the two formations have only one characteristic species, *Turris smithi* Arn., in common.

Partial List of Species in the Elk River Formation (Upper Pliocene), at the Seacliff North of the Mouth of Elk River, Port Orford, Oregon.

(F. F. Wood, H. Hannibal, collectors.)

PELECYPODA:

Cardium corbis Mart.[57]
Cryptomya oregonensis Dall.
Kennerlia grandis Midd.[57]
Leda acuta Conr.[57]
Macoma inquinata Desh.[57]
Macoma nasuta Conr.[57]
Modiolus modiolus L.[57]
Modiolus rectus Conr.[57]
Mya truncata L.[57]
Mytilus californianus Conr.[57]
Mytilus edulis L.[57]
Paphia staminea Conr.[57]
Pecten caurinus Gld.[57]
Psephidia lordi Baird.[57]
Saxidomus giganteus Desh.[57]
Siliqua nuttalli Conr.[57]
Spisula cf. albaria Conr.
Spisula falcata Gld.[57]
Spisula voyi Gabb (*S. alaskana* Dall).[57]
Thracia trapezoidea Conr.
Venericardia ventricosa Gld.[57]

GASTEROPODA:

Amphissa corrugata Rve. and var. *versicolor* Dall.[57]
Argobuccinum oregonense Redf.[57]
Bela tabulata Cpr.[57]
Boreotrophon gracilis Perry.[57]
Boreotrophon stuarti Baird.[57]
Buccinum strigillatum Dall.[57]
Calliostoma costatum Mart.[57]
Caesia fossata Gld.[57]
Caesia perpinguis Hds.[57]
Calyptraea fastigiata Gld.[57]
Chrysodomus phoeniceus Dall.[57]
Chrysodomus tabulatus Baird.[57]
Columbella gausapata Gld.[57]
Epitonium hindsii Cpr.[57]
Lacuna vincta Mtg.[57]
Lepeta concentrica Midd.[57]
Margarites pupilla Gld.[57]

[57] Species still living.

FIG. A.

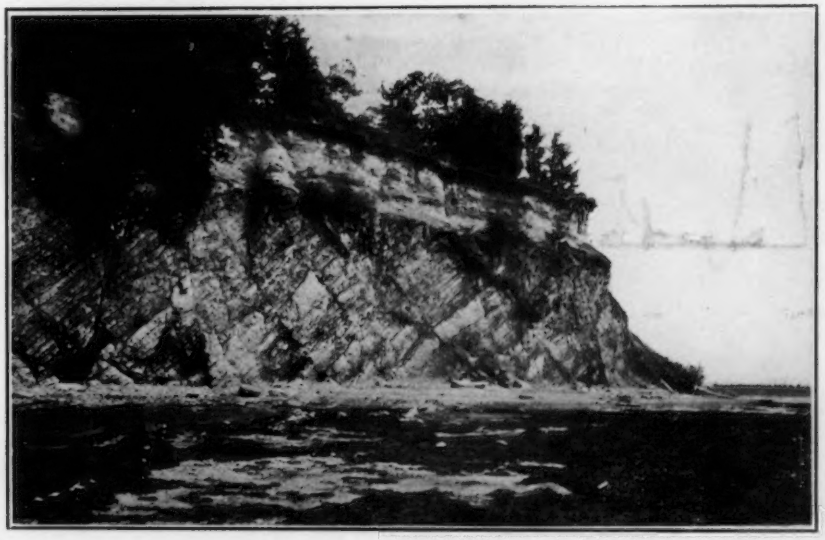

FIG. B.

FIG. A. Glacial grooving of Vancouver greenstone-diorites at entrance to Victoria Harbor, Vancouver Island.

FIG. B. Seattle shale (Astoria series) overlain by Pleistocene sands. Ilwaco. Washington.

Natica clausa B. & S.[57]
Nucella decemcostata Midd. (*Purpura lima* auct.).[57]
Nucella lamellosa Gmel. (*Purpura crispata* Chem.).[57]
Nucella saxicola Val.[57]
Olivella biplicata Sby.[57]
Olivella pedroana Conr.[57]
Polinices draconis Dall.[57]
Polinices pallida B. & S.[57]
Puncturella galeata Gld.[57]
Purpura foliata Gmel.[57]
Sipho halibrectus Dall.[57]
Solariella cidaris A. Ad.[57]
Trichotropis cancellata Hds.[57]
Tritonalia lurida Midd.[57]
Tritonifusus rectirostis Dall.[57]
Turris perversa Gabb.[57]
Turris smithi Arn.

BRACHIOPODA:
Hemithyris psittacea L.

ECHINODERMATA:
Scutella oregonensis Clark.

THE SAANICH FORMATION (PLEISTOCENE).

Benching the Oligocene and glacial deposits at Alki Point and Bainbridge Island in Puget Sound, filling glacial depressions at various points north of Victoria on the Saanich Peninsula of Vancouver Island, and terracing the length and breadth of the Straits of Georgia notably the Sucia Islands is a raised beach deposit for which the writers propose the name Saanich Formation. This formation carries numerous mollusca, usually species now living in adjacent waters, but others extinct or like *Pecten islandicus* Müller, *Cardium decoratum* Grnk. and *Mya arenaria* L. are now native only off the Alaska coast or at other arctic points. In this respect it resembles the lower San Pedro fauna which contains species now confined several hundred miles or more northward.

Overlying the marine deposits in several glacial hollows on the Saanich Peninsula are peat and marl beds containing numerous freshwater shells, the species being identical with those found in adjacent lakes. It appears that after the Post-Saanich elevation

[57] Species still living.

these hollows were filled by freshwater lakes and gradually silted up as Swan Lake and others on the Saanich peninsula are yet doing.

With the Saanich formation are tentatively included the widespread raised beaches on the west coast of Oregon and Washington containing marine shells at Cape Blanco, Bandon, and Newport in the former state and at Bay Center in the latter. Reagan[58] mentions the occurrence of marine shells in Pleistocene deposits at Beaver Prairie on the Olympic Peninsula, but the locality here is an old kitchenmidden.

Partial List of Species in the Saanich Formation (Pleistocene) of Puget Sound and the Straits of Georgia.

PELECYPODA:

Cardium corbis Mart.
Cardium decoratum Grnk.[59]
Macoma calcarea Gmel.
Macoma inquinata Desh.
Macoma nasuta Conr.
Mya arenaria L.[59]
Mya truncata L.
Mytilus edulis L.
Paphia staminea Conr.
Paphia tenerrima Conr.
Pecten islandicus Müll.[59]
Pecten hastatus hericeus Gld.
Saxicava arctica L.
Saxidomus giganteus Desh.
Serripes groenlandicus Gmel.
Schizothaerus nuttalli Conr.

GASTEROPODA:

Buccinum percrassum Dall.
Natica clausa B. & S.
Nucella lamellosa Gmel.
Polinices lewisii Gld.

GEOLOGICAL HISTORY.

The Coast Range of Oregon and the Willamette Valley.

The Coast Range, Willamette Valley, and Cascade Range of Oregon as has been intimated in the discussion of the Arago lavas were apparently built up during Eocene time as a gently westward

[58] Geological Papers Kans. Acad. Sci., 1908, p. 229.
[59] Species now native only to northward.

FIG. A.

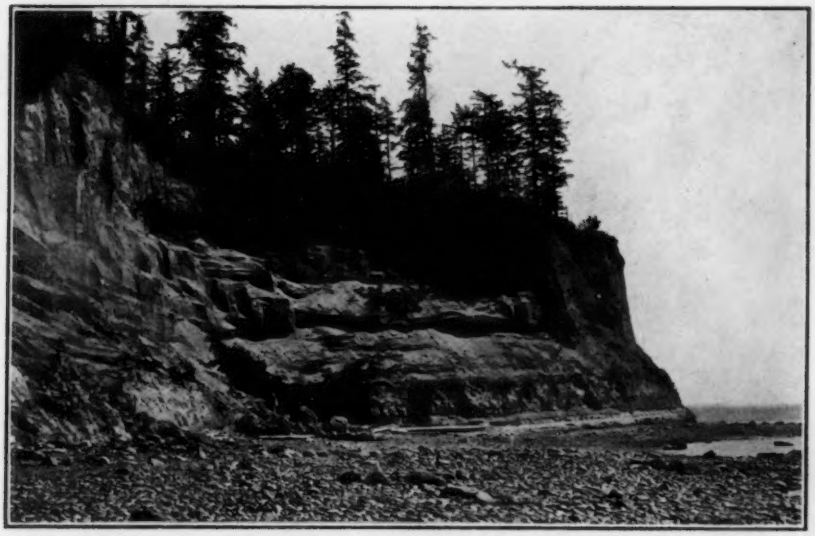

FIG. B.

FIG. A. Steilacoom gravels (outwash of Vashon drift), prairie between Gate and Olympia, Washington.

FIG. B. Glacial deposits at south end of Marrowstone Island, Port Townsend, Washington.

sloping floor of successive basaltic flows and tuffs. In the Cascade Mountains intercalated sediments are reduced to a minimum but farther to the west and south they apparently replace more and more the igneous materials. With the close of the Tejon this floor was elevated into the form of a plateau with a synclinal sag at the present position of the Willamette Valley. At the opening of the Astoria period of sedimentation an arm of the sea extending up the Willamette Valley at least as far as Eugene connecting across the Range at Wren and Blodgett but it was not until the Seattle Epoch that the Coast Range was completely submerged by the load of igneous and sedimentary detritus piled upon it, for at many points on the west flank particularly near Nehalem and Tillomook Harbors the Seattle beds rest directly on the Eocene with the lower Astoria (San Lorenzo) lacking. Following this, western Oregon was elevated and except for an embayment of the Monterey sea which extended up the Columbia River and southward to the Tualatin Valley west of Portland, no later sediments have been deposited inland from the extreme western border. It is probable that the coast line has stood near its present position during much of late Tertiary time owing to the existence of an important fault paralleling the coast for many miles. Elevations on the east side of this fault have resulted in the removal of all the later and much of the early Tertiary deposits and submergences on the west side have carried the successive deposits even deeper beneath the sea.

Much has been written of the continuity of the Willamette Valley with the geosynclinal trough of the Great Valley of California, but facts do not bear this out. The Willamette Valley is the result of the differential erosion of soft shales and sandstones compared with the basalts which flank it. It is underlain at no great depth by Eocene deposits, igneous and sedimentary, which frequently stand up as monadnocks through the thin veneer of fluvial deposits and alluvium. The so-called "Willamette Sound" either refers to the Oligocene embayment or to the fluvial deposits in the Willamette Valley above Oregon City where a late Tertiary basalt flow impinged in passing down the lower Willamette and Columbia Rivers and temporarily dammed back the Willamette River.

The Chehalis Valley and Southwestern Washington.

The geologic history of this district during the Tertiary has been: *first* the deposition of the Tejon series chiefly as an estuarine deposit but with some associated lavas, mostly basalts; *second* the deformation of Tejon by folding in a west-east or northwest-southeast direction; *third* the successive deposition of the Astoria Series, and the Monterey, Empire, and Merced formations; *fourth* the final elevation of the Olympic and Cascade Mountains in Pliocene time and the resultant faulting, prevailingly in an east-west or north-south direction, of all the Tertiaries of southwestern Washington into a jumble of westward-dipping monoclinal blocks. Except locally in the proximity of faults, folding of the Oligocene and later strata of Washington is almost unknown.

The Tertiaries of the Periphery of the Olympic Complex.

The succession of events about the periphery of the Olympic complex is similar to that of southwestern Washington, except that the Tejon is very largely absent and the folding which succeeded it has left no record. On the west coast several isolated areas of Tertiary rocks have been faulted down into the Cretaceous, and thus preserved. A fault which requires special mention in this connection is the one which marks the north boundary of the Olympic Mountains, extending from the mouth of the Soo-es River south of Cape Flattery to Lake Crescent and the head of S'quim Bay an unbroken distance of more than eighty miles. On the south side except at the terminii all the adjacent rocks are pre-Tertiary. To the north lies the great monocline of northwestward-dipping Oligocene beds. It is probable that a second fault paralleling this lies in the trough of the Straits of Fuca else it is difficult to explain that remarkable topographic feature. The structure of the gently seaward-dipping Tertiary rocks of the southwest coast of Vancouver Island may also be readily explained by an assumption that such a fault exists.

Puget Sound is probably a pre-Pleistocene valley of erosion filled by glacial debris. It has been regarded as a structural depression,

but if this is true it is difficult to explain why all the Tertiary and older rocks exposed about its borders or at various points in it form an integral part of a series of northward- or southward-dipping fault blocks which cross its major direction at right angles.

Notes on the Geological Formation Names Applied to the Tertiary of the North Pacific Coast.

During his work in 1911 and 1912 the junior writer made a special endeavor to visit as many as possible of the type-sections of the formations described on the North Pacific Coast and data are at hand to decide the age and status of practically all, as shown on the accompanying table. Those not already discussed may be noted chronologically.

Thos. Condon, in Cope, 1880, "Corrections of the Geological Map of Oregon."[60] The Astoria shales and *Solen* beds have already been considered in connection with the identity of the Astoria Series.

C. A. White, 1888, 1899, "On the Puget Group of Washington Territory"[61] and "The Mollusca of the Puget Group."[62] Broadly speaking the Puget Group is the equivalent of the Tejon Series. It was described as a freshwater deposit, but this is hardly true. While molluscan remains of any kind are generally scarce, several species described as freshwater forms are well-known marine Tejon species. Exactly how much of the Tejon is represented by the Puget is somewhat uncertain, however, and will continue to be so until the various floras are described and the species characteristic of the different portions of the Tejon become known. The Pierce County coal field where the Wilkeston section first described by White is located, represents about 14,700 feet of beds. The lowest 2,000 feet at the Fairfax and Montezuma mines evidently belong to the Chehalis formation judging by the flora. The upper 10,000 or 12,000 feet of beds (Carbonado, Wilkeston and Burnett formations) are certainly later and probably represent the Olequa. The beds on the Duwamish River near Allentown, eastward to Newcastle and

[60] *Am. Nat.*, XIV., 1880, p. 457.

[61] *Am. Jour. Sci.* (3d ser.), XXXVI., 1888, pp. 443–450.

[62] Bull. 51, U. S. Geol. Sur., 1889, pp. 49–63.

Squak Mountain, and southward to Green River, so far as palæobotanical evidence goes are of Chehalis age. Those at Bellingham appear to be younger, though more than one horizon may be represented. In any event the continued use of the name Puget is very misleading since the Upper Puget, so-called, is earliest Tejon (Chehalis), and the Lower Puget is later Tejon.

A. C. Lawson, 1894, "Note on the Chehalis Sandstone."[63] This formation redefined has already been considered as a division of the Tejon.

J. C. Merriam, 1896, "Note on Two Tertiary faunas from the Rocks of the south coast of Vancouver Island."[64] The section between Muir and Coal Creeks west of Sooke where Dr. Newcombe collected for Merriam in the early 90's, and courteously accompanied the junior writer in 1912, is recognized as the type of the Sooke formation. Dr. Merriam states that he never intended to name a Carmanah Point formation but the name has passed into the literature. The beds at this point are San Lorenzo shales overlain unconformably by Monterey conglomerate in the cliff beneath the lighthouse. Dr. Newcombe's collection came from the San Lorenzo shales, from Sooke boulders in the Monterey, and from the Monterey itself. The list should be expurged. The one quoted from Dall was derived from the San Lorenzo beds at Bonilla Point; it requires some revision.

W. H. Dall, 1898, "A Table of the North American Tertiary Horizons Correlated with One Another and with Those of Western Europe with Annotations."[65] The "foraminiferal shales . . . conformably underlying the Tunnel Point beds at Coos Bay, Oregon" contain a characteristic San Lorenzo fauna. The portion of the Tunnel Point beds adjacent to the "foraminiferal shales" represent a sandstone phase of the San Lorenzo. However, the bulk of the type section and the beds from which the fauna listed by Dall[66] came are of Empire age being separated from the main Empire

[63] *Am. Geol.*, XIII., 1894, p. 436.
[64] *Bull. Dept. Geol. Univ. Cal.*, II., 1896, pp. 101–108.
[65] 18th Ann. Rept. U. S. Geol. Sur. (II), 1898, pp. 323–348.
[66] Prof. Paper 59, U. S. Geol. Sur., 1909, p. 15.

syncline by faulting. An angular unconformity marked by Pholas-borings may be observed in a niche of the seacliffs which form the type-section of the Tunnel Point beds.

The *Aturia* bed at Astoria lies in the Seattle formation. As *Aturia angustata* ranges through the Astoria series and Monterey formation up and down the Pacific Coast, its value as an index-fossil of a single horizon is doubtful. The term "Astoria sandstone" appears to have been intended to cover Condon's *Solen* Beds at Astoria as well as the sandstones intercalated with the Astoria shales in the steep bluffs behind the town.

Mytilus beds; based on a locality at the north end of Shoalwater Bay (more properly Willipa Harbor), Washington, containing *Mytilus condoni* Dall = *M. middendorffi* Grnk. This is the Empire sandstone.

Coos Conglomerate, basal Merced conglomerate overlying the Empire beds at Coos Bay, Oregon. This is not the Coos Group of Vermont geological literature which is Palaeozoic.

J. S. Diller, 1896–1903, "A Geological Reconnaissance in Northwestern Oregon";[67] "Roseburg Folio," U. S. Geological Survey, 1898; "Coos Bay Folio," U. S. Geological Survey, 1901; "Topographic Development of the Klamath Mountains";[68] "Port Orford Folio," U. S. Geological Survey, 1903. The Arago is recognized as a division of the Tejon. Its subdivisions, the Pulaski and Coaledo, appear to be of interest chiefly to the coal geologist. The Tyee sandstone from the fauna at Basket Point on the Umpqua River is probably the same horizon as is also the Umpqua formation. The Wilbur tuff is a lithologic phase of the Arago, a type of rock not uncommon on the North Pacific Coast where fossiliferous beds rest upon basic igneous flows and tuffs.

The areas of Oakland limestone are so small that in the absence of a recognizable fauna it can only be considered as a local division. If post-Eocene in age, as supposed, these may represent isolated San Lorenzo areas similar to those flanking the Willamette Valley.

The relations of the Empire formation have already been con-

[67] 17th Ann. Rept. U. S. Geol. Sur., 1896, pp. 441–520.
[68] Bull. 196, U. S. Geol. Sur., 1902, pp. 30–31.

sidered. To this horizon are referred the lower 475 feet of the Cape Blanco beds. The upper 75 feet, argillaceous sands with some calcareous nodules, are unconformable on the Empire beds and form the base of the Elk River Formation, here referred to the Upper Pliocene.

Willis and Smith, 1899, "Tacoma Folio," U. S. Geological Survey. Three divisions of the Lower Puget (middle and perhaps upper Tejon), the Carbonado formation, Wilkeston sandstone, and Burnett formation are named. So far no palæontological evidence has been advanced to insure their recognition beyond the limits of the Pierce County coal field.

R. Arnold, 1906, "A Geological Reconnaissance of the Olympic Peninsula."[69] The use of the Arago in place of Crescent, and Monterey in preference to Clallam has already been discussed. Other beds on the north coast of Washington mapped with the Clallam as undifferentiated Oligocene-Miocene are now assigned to one horizon or another of the Astoria series.

The Quinaielt formation is divided on palæontological grounds between the Empire and Merced formations.

A. B. Reagan, 1908, "Some Notes on the Olympic Peninsula."[70] Most of geological data in this paper are adopted from the one by the senior writer just mentioned. The Hoko River Pliocene, so-called, is an area of Monterey sandstone and conglomerate uncomformable on the Astoria series. The Raft River Pliocene contains a small but characteristic Empire fauna. The description of the Quillayute formation is based on the glacial filling of the valley of the Quillayute River. If Reagan had visited the locality from which the fossils he describes from the Quillayute were brought by the Indians, he would have found it to be about two miles from the Devils Club swamp where he says they occur, and the formation lithologically very different from what he describes. It is typical Empire sandstone.

C. E. Weaver, 1912, "A Preliminary Report on the Tertiary Palæontology of Western Washington."[71] Cowlitz formation; the

[69] *Bull. Geol. Soc. Am.*, XVII., 1906, pp. 451–468.
[70] Geol. Papers, Kans. Acad. Sci., 1908, pp. 131–238.

TABLE OF CORRELATION OF THE FORMATION NAMES APPLIED BY VARIOUS AUTHORS TO THE TERTIARY HORIZONS OF THE NORTH PACIFIC COAST.

	Formation.	Condon, 1880.	Merriam, 1896.	Dall, 1898.	Diller, 1896–1903.	Willis and Smith, 1899.	Arnold, 1906.	Reagan, 1908.
Pleistocene	Saanich							
	Vashon drift	.....	.....	.....	.....	Vashon drift		
	Admiralty till	.....	.....	.....	.....	Admiralty till	.....	Quillayute (type section)
Pliocene	Elk River	.....	.....	.....	Elk River; Cape Blanco (in part)			
	Merced	.....	.....	Coos conglomerate	Coos conglomerate	.....	.....	Quinaielt (in part)
Miocene	Empire	*Solen* beds (in part)	.....	*Mytilus* bed; Empire; Tunnel Point (in part)	Empire; Cape Blanco (in part)	.....	Quinaielt	Quinaielt (in part); Quillayute (fauna only); Raft River
	Monterey	*Solen* beds (in part)	Carmanah Point (in part)	Astoria sandstone (in part)	.....	.....	Clallam	Hoko
Oligocene	Astoria — Twin River	.....	.....	.....	.....	.....	Mapped with Clallam as undifferentiated Oligocene-Miocene	Clallam
	Astoria — Seattle	Astoria shale	.....	Astoria s. s. (in part); Astoria shale; *Aturia* bed	.....	.....		Clallam
	Astoria — San Lorenzo	*Solen* beds (in part)	Carmanah Point (in part)	Tunnel Point (in part); Foraminiferal shale.....	Oakland limestone?	.....		.....
	Sooke	.....	Sooke	Sooke				
		White, 1888–9.	Lawson, 1894.					
Eocene	Arago	.....	.....	Arago	Umpqua — Wilbur, Tyee; Arago — Coaledo, Pulaski	.....	Crescent tuffs	Crescent tuffs
	Tejon — Olequa; Chehalis	Puget Group	Chehalis sandstone	Puget Group	.....	Lower Puget — Burnett, Wilkeston; Upper Puget — Carbonado	.....	.....

].	Willis and Smith, 1899.	Arnold, 1906.	Reagan, 1908.	Weaver, 1912.
.....	Vashon drift			
.....	Admiralty till	.....	Quillayute (type section)	
part)				
e	.....	.....	Quinaielt (in part)	
part)	.....	Quinaielt	Quinaielt (in part) Quillayute (fauna only) Raft River	Montesano Chehalis (in part)
.....	.....	Clallam	Hoko	Chehalis (in part) Wahkiakum (in part) Blakely (in part)
.....	.....	Mapped with Clallam as undifferentiated Oligocene-Miocene	Clallam	
.....	.....		.....	Blakely (in part) Lincoln Creek (in part)
?	.....		.....	Wahkiakum (in part) Blakely (in part) Lincoln Creek (in part)
	.....	Crescent tuffs	Crescent tuffs	
.....	Lower Puget — Burnett / Wilkeston	.....	.....	Tejon
.....	Upper Puget — Carbonado	.....	.....	Lincoln Creek (in part) Cowlitz

fauna of the beds on the Cowlitz River below the mouth of Drew Creek is identical with that at Chehalis and Centralia in the lower Tejon (Chehalis formation).

Lincoln Creek formation; this is very vaguely defined. The area shown on the map comprises two different things, Chehalis beds underlying the basalts of the Balch syncline, and a conformable sequence of a late phase of the San Lorenzo formation and an early phase of the Seattle. The fauna listed appears to have come from the basal San Lorenzo beds at Oakville about fifteen miles away. The equivalent beds of Sinclair Inlet are apparently lower San Lorenzo, and those of the Cape Flattery section, like most of the rocks on the west coast of the Olympic Peninsula mapped by Weaver as Lower Miocene, are Cretaceous.

"Tejon formation." The exact use of this formation name in Washington is uncertain. The fauna listed appears to have come from the Olequa beds near Little Falls and on Coal Creek above Stella. If the term Tejon is used in the broad sense that it is by the writers then the reasons for separating the Cowlitz formation which contains a fauna much more closely allied to that at Fort Tejon in California are not apparent. If it is used in a restricted sense for the Olequa beds then it is obviously misapplied.

Blakely formation; this name seems to be intended to cover all the Oligocene-Lower Miocene deposits of the Puget Sound and north coast of Washington. The type-section on Bainbridge Island is the exact equivalent of the Astoria Series as recognized by the writers.

Wahkiakum formation; the Oligocene-Lower Miocene of southwestern Washington. The type-section is Monterey sandstone but many of the fossils listed came from the Astoria beds on Skamokawa and Grays Rivers.

Chehalis formation; the type section is Monterey and Empire, and the fossils listed a mixture of the shale faunas of the two.

Montesano formation; apparently intended as a local name for the Empire sandstone.

THE NOMENCLATURE OF MINERALS.

By AUSTIN F. ROGERS.

(*Received May 14, 1913.*)

About five thousand mineral names are in use or have been proposed.[1] These names are, of course, mainly varieties and synonyms. Many of them have been discarded and are gradually disappearing from the literature. Even some of the Germans are dropping such names as *kupferglanz* and *eisenkies* and are using the international names, chalcocite and pyrite in this instance. Thanks to the fifth edition of Dana's "System of Mineralogy" the synonymy has been pretty thoroughly worked out and most of the names used for the distinctive minerals are well established.

Though there are about five thousand mineral names, there are not more than a thousand distinctive minerals.[2]

The distinctive minerals are usually called "simple minerals," "definite minerals," "mineral species," or "definite mineral species." It is necessary to use some such term, for the word mineral is used (1) as a general term for the inorganic constituents of the earth's crust, (2) in a popular way for a metallic substance of commercial value that is mined or quarried and (3) in a restricted sense for a natural inorganic substance of definite chemical composition.[3]

The term most used is "mineral species," borrowing a biological term. In this connection it is interesting to note that a binominal

[1] The most complete list of mineral names available is found in the "Mineralogisches Taschenbuch" of the Vienna Mineralogical Society published at Vienna in 1911.

[2] In Dana's "System" and Appendices up to the year 1909, 951 minerals are given. In Groth's "Tabellarische Uebersicht der Mineralien" (1908) there are 829. In the "Mineralogisches Taschenbuch" of the Vienna Mineralogical Society (1911) there are 972 (including 22 hydrocarbons not given by Dana and Groth). So the number of distinctive minerals is, in round numbers, 1,000.

[3] For an interesting discussion of the use of the word mineral see an article by J. W. Gregory, *Trans. Institution of Mining Engineers,* 1909.

nomenclature like that now used for plants and animals was at one time used for minerals. In the first (1837) and second (1844) editions of Dana's "System of Mineralogy" binominal names[4] were given along with the usual names, mostly ending in *-ite*. Thus barite was known as *Baralus ponderosus* and celestite as *Baralus prismaticus*. The genus *Baralus* also included witherite, strontianite, and barytocalcite. Classes and orders were also recognized. The classification used then was the natural history classification of Werner and Mohs based upon external characters.

This gradually gave way to the chemical classification of Berzelius and the Swedish chemists. In the third edition (1850) of Dana's "System" the chemical classification was adopted and the binominal names, even as synonyms, were rejected.

A mineral species is a mineral with definite chemical composition and distinctive crystal form (or crystalline structure). "Definite" must be interpreted in the light of isomorphism, including mass-effect isomorphism first recognized by Penfield.[5] It is also necessary to recognize solid solutions of a kind different from isomorphism.[5a] Pyrrhotite,[6] for example, is a solid solution of sulfur, S, in ferrous sulfid, FeS. Nephelite,[7] is a solid solution of $NaAlSiO_4$, $KAlSiO_4$ and $NaAlSi_3O_8$, of which only the first two are isomorphous.

Crystal form must also be used in defining a mineral species for polymorphous minerals are distinct and are often strikingly different in physical properties as in the extreme case of diamond and graphite. Some of the dimorphous minerals have distinctive names (*e. g.*, calcite, aragonite) but there is a tendency to use a prefix before the first known mineral for the dimorphous form. Thus we have clinozoisite, paralaurionite, pseudowollastonite, metaboracite,

[4] These binominal names were first suggested by Dana in an article in the fourth volume of the *Annals of the New York Lyceum*.

[5] That is, in large molecules dissimilar elements or groups may replace each other. See *Amer. Jour. Sci.* (4), Vol. 7, p. 97, 1899.

[5a] Küster (*Zeit. für phys. Chem.*, Vol. 17, p. 367, 1895) maintains that a distinction should be made between solid solutions and isomorphous mixtures.

[6] Allen, Crenshaw, and Johnston, *Amer. Jour. Sci.* (4), Vol. 33, p. 193, 1912.

[7] Bowen, *Amer. Jour. Sci.* (4), Vol. 33, p. 49, 1912.

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and neotantalite for the dimorphous forms of zoisite, laurionite, wollastonite, boracite, and tantalite respectively.

Since the rise of colloidal chemistry the question of names for colloidal or amorphous minerals arises. Recently names have been proposed for a few of the naturally occurring amorphous numerals. These substances can hardly be excluded from the list of mineral species as they are definite in composition, unless we insist that a mineral must be crystalline in character. To obviate this difficulty Niedzwiedzki[8] has proposed the term *mineraloid* for the natural amorphous substances. Among examples of colloidal minerals or mineraloids are the following: ostwaldite = colloidal AgCl (buttermilcherz); jordisite = colloidal MoS_2; α-kliachite = colloidal $Al_2O_3 \cdot H_2O$; β-kliachite = colloidal $Al_2O_3 \cdot 3H_2O$; ehrenwerthite = colloidal $Fe_2O_3 \cdot H_2O$. The term sulfurite has been proposed for amorphous sulfur and metastibnite for amorphous antimony sulfid. Fortunately there are very few amorphous minerals which are definite enough to be recognized as distinct mineral species[9] but the application of colloidal chemistry to mineralogy will probably increase the number in the future.

Names are used not only for definite chemical compounds, which are often end members of isomorphous series, but also for isomorphous mixtures such as olivine, rhodolite, epidote, and pisanite; for double salts such as dolomite and monticellite; for pseudomorphs such as martite, arkansite, and hampshirite; for mechanical mixtures such as californite and azurlite; for semiprecious or ornamental stones such as bonamite and satelite; for artificial substances such as alite, cementite, silver-analcite, soda-leucite, and carnegieite; for group names such as orthoaugite, clinoaugite, glaucamphibole; and for numerous varieties based upon crystal habit (*e. g.*, adularia), structure (*e. g.*, pholerite, nemalite), color (*e. g.*, melanite, hiddenite, kunzite), unusual optical properties (*e. g.*, isomicrocline, neocolemanite), and variations in chemical composition due either to impurities, (*e. g.*, johnstonite) or to isomorphous replacement (*e. g.*, cuprogoslarite, paravivianite, titanaugite). Varietal names are

[8] *Centralblatt für Min. Geol. u. Pal.*, 1909, p. 661.

[9] Of the more common minerals only opal, bauxite, psilomelane, and allophane are amorphous.

rarely consistent or logical for they are not usually coördinate and not uniform for the various minerals. In the earlier editions of Dana's "System" varieties were greatly subordinated but in the fifth and in the current sixth edition varieties are again given prominence. As Miers[10] has emphasized, the non-essential properties of mineral have received too much attention. The recognition of this fact will naturally lead to the supression of varietal names as far as possible. While often convenient their use tends to confusion. For example iron-bearing sphalerite has been called marmatite. A sphalerite from Breitenbrunn, Saxony containing eighteen per cent. of iron was named cristophite. Where draw the line between marmatite and cristophite? Sphalerite usually contains more or less iron. If the iron content is notable or needs to be emphasized let it be called ferriferous sphalerite. No special name is necessary.

Names should serve two purposes, which are more or less distinct, namely convenience and accuracy. A name serves a convenient purpose for distinguishing a particular variety or kind of mineral found at a certain locality or one with striking properties found at several localities. But there are so many variations in the properties of minerals that the names multiply too rapidly. Accuracy is not attained for it is very difficult to correlate the different varieties and to define them accurately.

Isomorphism plays a very prominent part in explaining the chemical composition of minerals for many minerals are isomorphous mixtures of two end members. The gaps in isomorphous series are gradually being filled in.

The only satisfactory way of simplifying mineralogical nomenclature is, in my opinion, to name a mineral by its predominant molecule of the isomorphous series to which it belongs. If the mineral is described and named before the isomorphous relations are understood the name still stands for the predominant molecule present. The other names used for varieties, isomorphous mixtures, pseudomorphs, etc., should be discarded, except in a few cases to be mentioned later. Isomorphous mixtures may be indicated by qualifying terms, *e. g.*, ferriferous sphalerite instead of marmatite. The

[10] "Mineralogy," p. 2.

same method can be used with varieties. Thus we can use the term fibrous brucite instead of nemalite.

Such names as soda-orthoclase, natroalunite, ferrogoslarite, and manganocolumbite are ambiguous. Soda-orthoclase may mean an orthoclase in which a portion of the potassium is replaced by sodium or it may mean the sodium compound corresponding to orthoclase. The best method is to use a distinctive name for the monoclinic feldspar in which sodium predominates molecularly over potassium. For such a mineral, which has been found at several localities, Schaller[11] has proposed the name barbierite after the French chemist, Barbier. Note the inconsistency in these compound names. Ferrogoslarite is an iron-bearing zinc sulfate while manganocolumbite is a manganese niobate isomorphous with ferrous niobate. It might be well to restrict these compound names to artificially prepared members of isomorphous series not yet found in nature. Thus we could use the term soda-anorthite instead of carnegieite. The names silver-analcite, soda-leucite, zinc-römerite are examples.

If my suggestions are adopted a number of mineral names will be discarded. Embolite will be either cerargyrite (chlorargyrite) or bromyrite. Petzite will be auriferous hessite. Pisanite will be either cupriferous melanterite or ferriferous boothite. Hyalophane will be barium-bearing orthoclase. Mesitite will be ferriferous magnesite. Nigrine will be ferriferous rutile.

On the other hand, a few new names or resurrected old names will be necessary. Thus the name montebrasite would be resurrected for the basic lithium aluminum phosphate which is isomorphous with amblygonite, lithium aluminum fluo-phosphate. Very few new names will be necessary for synonyms and varieties can often be elevated to the rank of distinct mineral species.

Some exceptions to my rule should be made. The isomorphous mixtures of three or four common and important mineral groups now have distinctive names which should be retained. Thus we have oligoclase, andesine, labradorite, and bytownite in the plagioclase group. Olivine is a convenient name for the isomorphous

[11] *Amer. Jour. Sci.* (4), Vol. 30, p. 358, 1910.

mixture of magnesium and iron orthosilicates but the names hyalosiderite and hortonolite in the olivine group are hardly necessary. Epidote is an isomorphous mixture of basic calcium aluminum orthosilicate, clinozoisite, and basic calcium iron orthosilicate, not yet found. Hypersthene is an isomorphous mixture of magnesium metasilicate, enstatite, and ferrous metasilicate, not yet found. It might be well as assign arbitrary limits to olivine, hypersthene, and epidote. This must be done if the names are to be accurate. Dana uses the name hypersthene for orthorhombic pyroxene with ferrous oxid content of over ten per cent. For these various isomorphous mixtures arbitrary divisions similar to those used in the quantitative classification of igneous rocks might be used.

Are the names of mineral species to be arbitrary or can any system of giving names be used? Leaving out the binomial nomenclature there are three possibilities to consider.

1. *Chemical Names.*—As minerals are substances of definite chemical composition purely chemical names will appeal to some as being the simplest and best. But minerals are often complex in composition and the chemical names would be long and cumbersome. While accurate they are not convenient. Moreover the name of a mineral connotes certain physical properties. Calcite is more than calcium carbonate. It is calcium carbonate with certain definite physical properties. The chemist would obviate this difficulty by using the term α-$CaCO_3$ for calcite and β-$CaCO_3$ for aragonite. Except for the elements, perhaps, distinctive names are preferable to chemical names.

2. *Arbitrary Names.*—The names used at present are derived from the locality at which the mineral was first found, from the name of the person who discovered or described the mineral, or they are based upon some prominent physical or chemical characteristic. They are arbitrary and without system except that most of them end in *-ite* (from the Greek and Latin *-itis* or *-ites,* which was added to a word signifying a quality, use, or locality of the mineral). Among other terminations are *-ane, -ine, -ase, -ote, -ole,* and *-ome* while older names include galena, quartz, garnet, etc. Some of the names have a chemical significance but even they are

in part arbitrary. Cuprite might have been applied to any copper mineral but it is arbitrarily used for cuprous oxid.

3. *Combined Chemical and Arbitrary Names.*—Still a third method is an attempt to combine the chemical names with arbitrary root-names. This method is used to some extent at present. We have such names as natramblygonite, plumbojarosite, and manganocolumbite, for distinctive minerals. As emphasized before these names are ambiguous and so are objectionable. In fact all such compound names should be discarded, except as indicated above. For varieties, qualifying chemical terms can be used. For example we can use the term ferriferous goslarite instead of ferro-goslarite. For distinctive minerals such as natramblygonite, plumbojarosite, and manganocolumbite it is preferable to use distinctive names.

In a recent paper entitled "Suggestions for Mineral Nomenclature,"[12] H. S. Washington proposes a new system of mineral nomenclature. He uses as a root name for the acid radical of a mineral group the present name of a typical member of the group. This root name is modified by chemical terms to indicate the particular mineral. For the apatite group the root name is *apatate*. Apatite is calcium phosphapatate, pyromorphite is lead phosphapatate, while mimetite is lead arsenapatate. The root name for the sphalerite group is *sphaleride*.[13] The sulfids of this group are called sulsphalerides, the selenids, selsphalerides, and the tellurids, telsphalerides. Sphalerite itself is called zinc sulsphaleride, metacinnabar, HgS, is mercury sulsphaleride while tiemannite, HgSe, is mercury selsphaleride and coloradoite, HgTe, is mercury telsphaleride. Calcite is calcium calcitate, siderite is ferrous calcitate, and dolomite is magnesicalcium calcite. Forsterite is magnesium olivenate. Orthoclase is potassium adularate. Albite is sodium albate, etc.

Washington's proposed system emphasizes the isomorphous relations, but in my opinion that is about the only good point in its favor. As Washington himself admits, the names are barbarous and uncouth. Most of them are also long and cumbersome and so do not

[12] *Amer. Jour. Sci.* (4), Vol. 33, p. 137, 1912.

[13] The termination *-ide* is used for binary compounds and sulfo-salts while the termination *-ate* is used for the oxy-acid salts.

serve the purpose of convenience. For example, the name for the basic calcium phosphate for which I recently proposed the name voelckerite[14] would be something like calcium oxy-phosphapatate.

Arbitrary names I believe are preferable to names such as those proposed by Washington. My reasons are as follows:

1. Arbitrary names are stable; there is no necessity for change because of an incorrect analysis.

2. Any name of a new mineral that is proposed stands for the predominant molecule whatever its isomorphous relations may be.

3. Arbitrary names are more convenient than other names because they are shorter.

4. The present names are to a large extent retained and very few names will be necessary.

Most of the present names are so well established by long association that it will be almost impossible to substitute other names for them. The law of priority, with certain limitations,[15] holds in mineralogy as in zoölogy and botany.

Only the professional mineralogist would be apt to use Washington's system, but to him the arbitrary names are not objectionable.

There is one apparent objection that may be urged against my plan. A quantitative chemical analysis will often be necessary to place and name a mineral that is near the dividing line between two isomorphous compounds. This is unfortunate from the standpoint of determinative mineralogy but it is no real objection. It goes without saying that accuracy of definition is based upon accurate work which must often be quantitative in character. As Miers[16] says ". . . it cannot be too strongly impressed upon the student at the outset that scientific mineralogy is based upon accurate measurements and determinations."

There are several points to mention in connection with the recording of chemical analyses of minerals. I think it is well, as I have done in a recent text-book,[17] to record mineral analyses in the form of metals and acid radicals instead of the usual form of oxids. The

[14] *Amer. Jour. Sci.* (4), Vol. 33, p. 475, 1912.
[15] Dana, "System of Mineralogy," 6th ed., p. xliii, 1892.
[16] "Mineralogy," p. v.
[17] "Introduction to the Study of Minerals," New York, 1912.

present method is based upon antiquated notions dating back to electro-chemical theory of Berzelius. The ideal way would be to record the constituent elements. This can be done with haloids, sulfids, and sulfo-salts but not with the oxygen salts for there is no method of determining oxygen directly. If haloids or sulfids are combined with oxygen salts as in minerals of the apatite group there is decided advantage in recording percentages of the metals and acid radicals. In the silicates the acids and acid radicals are not known and it is necessary to use the ordinary oxids as in rock analyses.

In recording analyses it is well to give the molecular ratios of elements and acid radicals in addition to the percentage composition even if the purpose is not to establish a chemical formula.[18] This plan has been proposed for igneous rocks by Washington[19] but might well be extended to cover minerals. Murgoci[20] in an article on the classification of the amphiboles uses a tabulated list of the molecular ratios instead of the more usual percentage compositions.

My suggestions concerning mineral names are far from carried out at present. Out of Spencer's list[21] of about one hundred new mineral names proposed between the years 1907–10 approximately, not more than fifty-five can possibly be regarded as distinct mineral spaces. That is, forty to fifty names proposed within this short time are, in my opinion, practically useless. There are glendonite, pseudopirrsonite, and pseudostruvite, names for pseudomorphs. Fermorite, anemousite, spandite, and grandite are isomorphous mixtures. Spandite is an isomorphous mixture of spessartite and andradite, while grandite is an isomorphous mixture of grossularite and andradite. While these names may occasionally be convenient they only increase the difficulty of naming a mineral. The names are not exact for the limits are not defined. Azurmalachite, sefströmite, and leesbergite are mechanical mixtures. Alomite,

[18] The tables in Kemp's "Handbook of Rocks," 5th edition, pp. 171–177, will be found useful in converting percentage compositions into molecular ratios.

[19] *Amer. Jour. Sci.* (4), Vol. 10, p. 59, 1900.

[20] *Bull. Dept. Geol., Univ. of California Pub.*, Vol. 4, pp. 377 and 383.

[21] *Mineralogical Magazine*, Vol. 15, p. 415, 1910. For previous lists see ibid., Vols. 11, p. 323; 12, p. 378; 13, p. 363; and 14, p. 394.

bonamite, ricolite, satelite, and vredite are trade-names of semi-precious and ornamental stones. Aglaurite (orthoclase), bravoite (pyrite), hallerite (paragonite), cobaltocalcite (calcite), isomicrocline (microcline), loaisite (scorodite), neslite (opal), magnesium-pectolite (pectolite), pulleite (apatite), tawmawite (epidote) are simply varieties of the minerals indicated. Still other names are synonyms but these are often unavoidable.

The task of descriptive mineralogy is to establish and define the distinctive minerals or mineral species but the science is greatly handicapped by hundreds of varietal names which are worse than useless.

In conclusion let me urge that in the future new names be given to *bona fide* mineral species only and that distinctive names of varieties, pseudomorphs, and mixtures be discarded as far as possible.

STANFORD UNIVERSITY, CALIFORNIA.
May, 1913.

THE CHARACTER AND ADVENTURES OF MULADEVA.

By MAURICE BLOOMFIELD, Ph.D., LL.D.

(*Read April 18, 1913.*)

Any selection of Hindu fiction might fitly open with the only story that attempts a continuous account of Mūladeva's adventures, because Mūladeva is one of the very few figures in Hindu fiction that may be described as a "character." In general the personnel of Hindu fiction is made up of stock or lay figures. Such are, above all, the young prince, usually of ineffable beauty, virtue, strength and skill, who contrives to get himself separated from his happy home, and starts upon a career of adventure. This leads up to a union with a no less hyperbolically beautiful and virtuous princess. The hero, for his part, is liable to be carried off by a mettlesome horse into the wilderness, where his adventures begin. He is pretty sure to come upon the heroine in some unpleasant predicament, such as a prospective uncongenial marriage, or, when she is in some personal danger. *E. g.,* times without end, the hero saves the beautiful maiden from an infuriated elephant, usually by throwing his upper garment before the elephant's trunk.[1] Or, quite in the manner of St. George and the dragon, he saves the princess from a bloodthirsty Rākṣasa.[2] In the end he marries her, and she, incidentally, bestows her father's kingdom upon him.

Very frequently the prince is attended by a faithful friend, perchance the son of his father's chief minister. The two, as boys, had played in the sand together, that is, had made mud-pies together.[3] This friend is prone to display much heroism and self-sacrifice in behalf of the prince: he is a stock figure of the better sort. Simi-

[1] Kathāsaritsāgara 89; Story of Bambhadatta, in Jacobi's "Ausgewählte Erzählungen," p. 16, l. 19 ff.; "Story of Agaḍadatta," ibid., p. 71, stanzas 53 ff.

[2] Kathāsaritsāgara 79; Vetālapañcaviṅçati 5.

[3] Such a person is called in Sanskrit, pāṅsukrīḍita (Pariçiṣṭaparvan, p. 123; cf. Harṣa-Carita 1, Bombay edition, 1897, p. 17; in Pāli, paṅsukīlita (Jātaka 83 and 519); Mahāvāstu 3. 451; in Prākrit, paṅsukīliya, Jacobi's "Ausgewählte Erzählungen," p. 20, l. 16.

larly, the heroine has a faithful female friend, who is almost invariably the go-between, or love's messenger (*servus currens*) between herself and the hero. The lady, as a rule, takes the initiative, by look or act, in establishing relations with her lover-to-be.

Comfortably settled kings, in their maturer years, are also taken with a kind of "wanderlust," and roam in search of adventures.[4] Merchants and merchants' sons start on quests of trade and wealth; travel to a great distance; suffer ship-wreck; are rescued by dangerous sirens; are destroyed by them; or attain in the end marvelous prosperity. Holy men, gifted with supernatural powers, wander about; whensoever they are treated properly they secure the happiness of deserving lay persons. On the other hand, all sorts of rogues in the guise of holy men play tricks under the mantle of their sanctity, usually to meet with discomfiture and disgrace in the end. Faithful or faithless wives; noble or degraded courtezans; gamblers, thieves, and robbers are further instances of the stereotyped dramatis personæ of Hindu fiction. To a very considerable extent all these adventures are lifted to a higher plane of romanticism by the interference, or *deus ex machina* coöperation of supernatural beings: benign gods, magic-loving Vidyādharas, Yakṣas, and heavenly nymphs, called Apsaras. And all persons, divine or human, operate with supernatural agencies: magic objects that grant wishes, or perform wonderful acts; powerful charms; the forecast of dreams; the prophecies of holy men and women.

The adventures of all these personages contain as a rule no very continuous plots. They usually consist of a chain of salient, individual, romantic episodes, strung together, one after another. Quite frequently, one or the other of the happenings are in the nature of an anecdote, or prank, or trick which one person in the story plays upon the other. In this latter phase of fiction puns and riddles often play a part. The separate events of a story rarely unfold character, and do not necessarily contribute to such *dénouement* as the story may happen to have. There is the familiar boxing of story within story, and frequently the events told in one and the same story are really different events which merely overlap each other at some one point.

[4] See Prabandhacintāmaṇi, Tawney's Translation, pp. 12, 30, 42.

The real interest of Hindu fiction lies in the ingenuity, imaginativeness, and shrewdness of each unit of story-telling. Taken in bulk, these stories seem fairly to exhaust all the permutations which can be imagined to arise from the juncture of real or fictitious persons and things with the circumstances of time and place. Therefore, the individual motifs of story or fairy-tale, as found with other peoples, seem to hold a kind of mass-meeting on the great arena of Hindu fiction. As is well known, the ancient treasury of narrative which India pours out lavishly from the time of the Rig-Veda to this day, passed freely beyond the bounds of India. Not only the stories and fables of entire cycles, such as the Pañcatantra, or the 'Seventy Tales of the Parrot,' were exported bodily and taken over by other literatures, but numberless individual stories and individual story traits penetrated to the farthest ends of the earth. It is, at any rate, rather hard to find, in the rest of the world, fable or fiction traits of marked character which do not own to an Indian analogon; many a time they may, at least, be suspected to be of Indian origin. As a corollary to this last condition, nearly all the more important motifs are intensely repetitious in the Hindu narratives themselves, so that, as a matter of external experience, there are neither absolutely original fables or stories, nor absolutely original collections of such fables or stories.

With all this wealth of themes, and the clever way in which they are worked up, the Hindu story rarely goes beyond the limits of a sort of thin novelette. Real types of men and women are, as a rule, either wanting, or they are indicated by crude, sometimes contradictory delineation. The biography of Mūladeva, though dwelled upon with some insistence, is no exception to the rule; yet it fulfils to a certain extent more modern requirements as regards delineation of character. The stories told about him show more real sequence, closer interlocking of cause and effect than is customary in Hindu fiction.

The most important story of Mūladeva is preserved in Devendra's Vṛtti, a sort of commentary on the Jain text called the Uttarādhyāyana. Mūladeva, moreover, figures in an autobiographic episode of his own life, narrated by himself to a king in Kathāsaritsāgara

124, or at the end of the tenth book of the Bṛhatkathāmañjarī. Again, in the fifteenth 'Tale of the Vampire' (Vetālapañcaviṅçati), he acts a Mephistophelic part in involving a princess in two marriages, arranged so trickily that it is hard to say which husband she really belongs to. Mūladeva figures occasionally in other stories; in addition, a lively tradition of a very variegated sort shows that he has fixed himself as a "character" in the imagination of the Hindu people through many centuries. Yet even Devendra's biography is rather in the nature of an impressionist sketch than a well-knit novel. Nor is his characterization in tradition as a whole by any means consistent: he has traits of Simplicissimus, Tyl Eulenspiegel, Cagliostro, Mephisto, and others. On the whole he is a rogue whose pranks have endeared him to the popular heart as a shifty, yet delectable figure, who may however, as in Devendra's story, occasionally be taken more seriously and padded out into a sort of hero.

The life history of Mūladeva fitly begins with his own name,[5] which seems to mean "Wizard," literally, "He who makes roots his divinity." Within the sphere of narrative in which Mūladeva figures, magic practices by means of roots are still as familiar as they were in the time of the Atharva-Veda.[6] Mūladeva is identified, next, with Karṇīsuta,[7] an author on the "Science of Thieving" (steyaçāstra-pravartaka). Karṇīsuta is said to be a Karaṭaka, some sort of gentile designation. In Daçakumāracarita, Apahāravarman, one of the princes who narrates his own adventures, himself a great scoundrel, tells how he decided to follow the way of Karṇīsuta, in order to teach the misers of a certain city the instability of wealth, by the simple device of stealing that wealth. At the end of the same story King Rājavāhana, after hearing Apahāra-

[5] Cited by the Kāçikā at Pāṇini 8. 2. 18.

[6] See Bloomfield, "The Atharva-Veda," General Index, p. 135[b]; Schmidt, Beiträge zur Indischen Erotik, pp. 739, 740; Prabandhacintāmaṇi (Tawney's Translation), p. 191.

[7] In the Lexicon called Hārāvalī, as cited by the commentary to Subandhu's Vāsavadattā; see Weber, "Indische Streifen," i. 383, note 2; Pavolini, GSAI. ix. 176; Meyer's translation of Daçakumāracarita, pp. 215, 244. Bālakṛṣṇa to Bāṇa's Kādambarī, in a roundabout fashion, also makes the same identification; see p. 621.

varman's rascally story, exclaims: "Why, you have gone Karṇīsuta's rough practices one better!"

Karṇīsuta goes, all told, by four names: (1) Mūladeva. (2) Mūlabhadra, perhaps, "Servant of Roots": the name is little more than an equivalent of Mūladeva. (3) Kalāṅkura, "Shoot of Accomplishments," that is, "Product of the 64[8] kalā's," or accomplishments, which belong to a *routiné* man of the world, or man about town, the typical nāyaka or "hero," a sort of "devil of a fellow," as he is sketched ideally and systematically in the scheme of the (to us) villanous Kāmaçāstras,[9] or "Love-Bibles" of India. (4) Karṇīsuta (Karṇīcuta[10]), and Karṇīputra, *i. e.*, "Son of Karṇī," a mother about whom we hear nothing, perhaps a courtezan. Else we should, according to Hindu models, expect a patronymic, rather than a metronymic. "Sons of maidens" (kumārīputra, kānīna) are well-known in Sanskrit literature, *e. g.*, VS. 30. 6; TB. 3. 4. 1. 2; Manu 9. 160, 172. In the two Vedic texts he typifies lust or pleasure (pramad, pramud).

This fourth name is similar to that of a frequently mentioned author of amatory literature, namely Goṇīputraka, Goṇikāputra, and Goṇikāsuta, *i. e.* "Son of Goṇī or Goṇikā." In the introduction to the Pañcasāyaka, "Five arrows (of the God of Love)," occurs the expression goṇīputraka-mūladeva-bhaṇitam, which looks for all the world as tho it meant "Mūladeva, the Son of Goṇī." In the same text Goṇīsuta and Mūladeva are mentioned once more, tho not side by side, as authorities; no other authors are mentioned at all. This also looks as tho the names were interchangeable, especially when we consider that the text is metrical and is liable to require differing quantities in a tetrasyllable; see Richard Schmidt, "Beiträge zur Indischen Erotik," p. 918 ff. The same author, p. 46, remarks

[8] Prabandhacintāmaṇi, p. 32, counts 72 accomplishments. So also Devendra, in the story of Agaḍadatta (Jacobi's "Ausgewählte Erzählungen"), stanza 22. See the list in Prabhāvaka-Carita (ed. Hīrānanda U. Sharmā), p. 132.

[9] Not so the Hindus. They regard the Kāmaçāstra as a legitimate Çāstra. *E. g.*, in the Prabandhacintāmaṇi, p. 63, Vātsyāyana's Kāmaçāstra is regarded as on a par with the three Vedas, the Raghuvaṅça, and the Arthaçāstra (Kāuṭilīya) of Cāṇakya.

[10] This spelling due, perhaps, to Prākrit cuta "fallen," the standard expression for passing from a higher to a lower existence in the course of transmigration.

that Goṇīputra, and the like, are metronymics of an author whose real name is no longer known. It is probable, therefore, that Mūladeva, Karṇīputra, and Goṇīputra are one and the same man. In any case there is no occasion for scepticism as regards the identity of Mūladeva and Karṇīsuta. Bāṇa's Kādambarī (Peterson's edition, p. 19, l. 16) states that the Vindhya forest, like the story of Karṇīsuta, had its Vipulācala and Çaça. This is euphuistic indirection (vakrokti) for, "it had extensive mountains and was frequented by hares." The word for mountain is acala, and the word for hare is çaça. These two words figure in the Mūladeva legends as proper names of persons, and thus make out a mathematical equation between Mūladeva and Karṇīsuta.

So much for the name. As regards Mūladeva's character we may begin with his performances as an author. In Kṣemendra's Kalāvilāsa,[11] a satirical treatise on the foibles or tricks inherent in sundry walks of life, Mūladeva appears as the mentor (a sort of Viṣṇuçarman) of a young merchant's son, Candragupta. Mūladeva is designated as dhūrtapati, "prince of rogues." As such he is supposed to be a fit teacher of a young man of wealth and family, the point being that Mūladeva is best able to save a youth from the pitfalls of rogues and courtezans.

Next, he is, as was pointed out above, shining authority on kāmaçāstra: the Pañcasāyaka refers to him several times on intimate questions of the *ars amatoria*.[12] This is supported by a text called Çaktiratnakara, which deals with the secret cult of Durgā; he is there mentioned along with a set of kāmaçāstra authors which for the most part are cited elsewhere in this sphere of literature.[13] If my surmise is correct, that Goṇikāputra is no other than Mūladeva himself, his authority in this line of literature rises in the scale. Incidental mentions in literature show his adroitness not only in

[11] The text is published in the series Kāvyamālā, fascicles 1 and 2 (1886). An analysis of its contents is given by J. J. Meyer, in the Introduction to his translation of the Samayāmātṛkā, pp. xl ff. Cf. also Sylvain Lévi, "La Bṛhatkathāmañjarī de Kṣemendra," p. 11 (reprint). In Çukasaptati, 23, the merchant Candra entrusts, similarly, his son to the pander Dhūrtāmāyā, to teach him the wiles and tricks of bad women.

[12] See Schmidt, "Beiträge," pp. 50, 879, 919.

[13] See Charpentier, "Paccekabuddhageschichten," p. 58.

practices, but also in wise saws pertaining to love. In Kathāsaritsāgara 98 (Vetālapañcaviṅçati 24) a son encourages his widowed father to marry again, by means of a stanza composed by Mūladeva: "Who, that is not a fool, enters that house in which there is no shapely love eagerly awaiting his return, which tho called a house, is really a prison without chains?" A scholiast to the Saptaçataka of Hāla[14] cites a hemistich by Mūladeva of quite similar import: "It's no use anointing yourself with fragrant unguents, if you haven't a light-o'-love." In the 30th Story of the Parrot (Çukasaptati) two demons (piçācas) quarrel over the beauty of their respective wives. They catch hold of Mūladeva, who is to decide. He, thinking in his soul that both their she-devils are passing ugly, wriggles out with the verse: "To every lover in the world she alone seems charming that is his love; no other." The same riddle in Mahābhārata, Kathāsaritsāgara, and in the story of Oedipus; see Tawney's note to his Translation of Kathāsaritsāgara, i. 26.

Mūladeva is, however, not merely the theoretic academician of love. Tradition has him the practical promoter of love: wherever there be some beauty to conquer, either on his own account, or on the account of others, he pushes himself forward. More especially, in love-affairs of the shady sort, Mūladeva is the standard resort. Or, he plays the part of a mischievous devil in connection with illicit loves. Thus, as regards the last point, in the "Tales of the Parrot," 22, a farmer's wife who is in the habit of carrying him his dinner amuses herself with her paramour on the way. She deposits the dinner-kettle on the road, and Mūladeva puts in camel's meat. When her husband inquires suspiciously she, quick as a flash, answers: "Sir, I dreamt that you would be eaten by a camel, and have played this prank to nullify the omen." Another time, in an unsavory little story told in the Jain Āvaçyaka Niryukti, Mūladeva is on the road with a boon companion, a sort of *fidus Achates,* who is here named Kaṇḍarīka. They come across another traveler with his wife. When Kaṇḍarīka is smitten with the charms of the woman, Mūladeva tricks the husband.

Mūladeva climbs to the pinnacle of tricky mischief, as "lord of

[14] Cf. Weber, Das Saptaçatakam des Hāla, p. xxv.

rogues" in affairs of love, in the 15th Vampire story, as told in the Kathāsaritsāgara 89, or the 14th story in Çivadāsa's version of the same book. A young Brahman, Manaḥsvāmin, saves the life of a princess Çaçiprabhā from an infuriated elephant. The two young people, of course, fall madly in love with each other. Manaḥsvāmin, who is not eligible, goes to visit that master of magic, Mūladeva. Then that matchless deceiver places a magic globule into his mouth, and transforms himself into an ancient Brahman. He gives a second globule to Manaḥsvāmin, who turns into a beautiful maiden. And that prince of villains took him in this disguise to the judgment-hall of the king, the father of his lady-love, and said to him: "O king, I have only one son, and I asked for a maiden to be given him to wife, and brought her from a long distance. But now he has gone somewhere or other, and I am going to look for him; so keep this maiden safe for me, until I bring back my son; for you keep safe under your protection the whole world."[15] Needless to say, the king accepts the charge; gives Manaḥsvāmin as a companion to Çaçiprabhā; the two marry by the Gandharva rite; and Manaḥsvāmin is a woman by day and an ardent lover by night, using the simple device of putting in and taking out the magic globule.

In time the brother-in-law of the king gives his daughter, Mṛgāṅkavatī, in marriage to the son of his minister. The princess Çaçiprabhā is invited to her cousin's marriage, and goes there with her ladies-in-waiting, including Manaḥsvāmin, wearing the form of a young maiden of exquisite beauty. The fresh bridegroom becomes distracted with love on beholding Manaḥsvāmin. There were no difficulty in his marrying Manaḥsvāmin as a second wife, but how can the king who has him (or her) in keeping for another husband, a Brahman's son, permit this marriage? It is decided to send the minister's son on a journey of six months; if, when he returns, the Brahman has not come back to claim the maiden, he may marry her also. Manaḥsvāmin, the trick-maiden, remains behind with Mṛgāṅkavatī. The two girls become very affectionate, until finally

[15] The same ruse in similar stories, Çukasaptati 62; Pramati's adventure, Daçakumāracarita 5; Kathāsaritsāgara 7. 40–87; Vīracarita 8 (*Indische Studien*, xiv. 153 ff.).

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the pupil of that master-rogue tells her: "I have a boon from Viṣṇu, by which I can at pleasure become a man during the night, so I will now become one for your sake." Then they elope before the minister's son, the husband of Mṛgāṅkavatī, returns to claim the man-woman Manaḥsvāmin, who had been promised him as his second wife.

One should think that Mūladeva would be content with the impish mischief done so far. Not he. Again he takes on the guise of the old Brahman, turns his Leporello (who is this time called Çaçin) into a young Brahman, his supposed son, and goes to claim Manaḥsvāmin as his daughter-in-law from the fiduciary king. The latter is, of course, unable to deliver the goods, and, afraid of the feigned stern Brahman anger of Mūladeva, gives his own daughter Çaçiprabhā to Çaçin, by way of compensation.

Then Mūladeva takes this bridal couple to his own home, where Manaḥsvāmin meets them, and a fierce dispute takes place between the latter and Çaçin in the presence of that Mūladeva. Manaḥsvamin says: "This Çaçiprabhā should be given to me; for, long ago, when she was a maiden, I married her by the favor of the master (*i. e.*, Mūladeva)." Çaçin says: "You fool, what have you to do with her? She is my wife, for her own father bestowed her on me in the presence of the fire." The story cleverly dodges the decision of the dispute.

There is one charming story which Mūladeva narrates to the famous legendary king Vikramāditya, as illustrating the virtue and resourcefulness of a true wife. It is told in Kathāsaritsāgara 124, and, in a poor digest, in Bṛhatkathāmañjarī 10. 272 ff. As behoves the atmosphere of our hero, it is full of quips and pranks, but the joke is rather on Mūladeva, who narrates it with a sort of humorous self-persiflage. Mūladeva, in company with Çaçin, arrives at Pāṭaliputra, and, after some witty preliminary passes, full of give and take, with some of the inhabitants,[16] Mūladeva falls in love with a saucy Brahman's daughter who had shamed them by her wit. He ingratiates himself with her father, and manages to marry her; she

[16] The quip with the mango-fruits recurs in Prabandhacintāmaṇi (Tawney's Translation), pp. 5, 6.

does not remember that they had previously exchanged repartee. At night he recalls himself to her memory, when she says: "Yes, country bumpkins are tricked in this way by city wits." Then he replies: "Rest you fair, city wit; I vow that the country bumpkin will desert you and go far away." She then vows in her turn that a son of hers by him shall bring him back again. He puts a ring on her finger, and promptly makes off to Ujjayinī, in love with her, but wishing to make trial of her cleverness.

Then the Brahman's daughter starts off to Ujjayinī in the guise of a splendidly equipped hetæra, calling herself Sumaṅgalā. There she poses as the beauty of the world, a position which she is able to maintain through her father's wealth and her own charm. She is approached by many suitors, but manages to elude them. Mūladeva narrates with gleeful unction, how his own friend Çaçin was chased from pillar to post in an attempt to reach her. Finally Mūladeva himself is admitted to her presence and favor. He does not recognize her as his own wife, but lives with her in great mutual love for some time, until she forges a letter from her supposititious sovereign, and disappears as she came, returning, of course, to her home in Pāṭaliputra.

In due time she gives birth to a boy by Mūladeva. This boy, at the age of twelve, is wonderfully accomplished. In a quarrel he beats with a creeper a fisher-boy who is, of course, of low caste, and the boy throws into his teeth: "You beat me, tho nobody knows who your father is; for your mother roamed about in foreign lands, and you were born to her by some husband or other."[17] The boy then extracts from his mother the whole story, including his father's name, and finally exclaims: "Mother, I will go and bring my father back a captive; I will make your promise good!"

At this point Mūladeva's own narrative becomes too good to be shortened. "The boy set out and reached this city of Ujjayinī. And he came and saw me playing dice in the gambling-hall, making certain of my identity from the description his mother had given him, and he conquered in play all who were there, and he astonished every one there by showing such remarkable cunning, tho a mere child.

[17] Cf. Prabandhacintāmaṇi, p. 170.

Then he gave away to the needy all the money he had won at play. And at night he came and stole my bedstead from under me, letting me down gently on a heap of cotton while I remained asleep." We must remember that gambling is Mūladeva's pet vice which brings him to grief in Devendra's novel, and that, furthermore, he is "prince of thieves," author of a steya-çāstra or "thieves' bible." Stealing a bedstead from under such as he, is like stealing the white of Sherlock Holmes' eyes. Mūladeva continues: "So when I woke up, and saw myself on a heap of cotton, without a bedstead, I was at once filled with mixed feelings of shame, amusement, and astonishment. Then, O king, I went at my leisure to the market-place, and, roaming about, I saw there that boy selling the bedstead. So I went up to him and said: 'For what price will you give me this bedstead?' Then the boy said to me, 'You cannot get the bedstead for money, O crest-jewel of cunning ones; but you may get it by telling some strange and wonderful story.' When I heard that I said to him, 'Then I will tell you a marvelous tale. And, if you understand it and admit that it is really true, you may keep the bedstead; but if you say that it is not true and that you do not believe it, you will be illegitimate, and I shall get back the bedstead. Now listen! Formerly there was a famine in the kingdom of a certain king; that king himself cultivated the back of the beloved of the boar with great loads of spray from the chariot of the snakes. Enriched with the grain thus produced the king put a stop to the famine among his subjects, and gained the esteem of man.'

"When I said this the boy laughed and said: 'The chariots of the snakes are the clouds; the beloved of the boar is the earth, for she is said to have been most dear to Viṣṇu in his boar incarnation; and what is there to be astonished at in the fact that rain from the clouds made grain to spring on the earth?'"

The boy then, in his turn, poses a cosmic-mythological riddle—dear to the heart of the Hindu from the time of the theological brahmodya of the Veda—on the condition that, if Mūladeva solves it, he gets the bedstead; if not he becomes the boy's slave. Of course, Mūladeva fails; the boy takes hold of his arm, and takes him to his mother in Pāṭaliputra. Mūladeva, the unstable scape-grace, lived

there "a long time" with that wife and that son, and then returned to Ujjayinī, unable to keep steady company for ever.

Mūladeva is not merely versed in the direct arts, practices, and tricks of love; he is also celebrated in all accessories. He is a cultivated conversationalist; brilliant narrator; marvelous musician; expert in massage, perfumes, and ointments;[18] knows how to send a lady a present; in fact, man of the world and *arbiter elegantiæ*, or according to the Hindu Love-Bibles, a typical nāyaka, or "hero," who must really control no less than sixty-four accomplishments. These qualities come to the fore in Devendra's story.

In the broader sphere of tradition he, or his double Karṇīsuta, is a dhūrtapati, "master-thief," and author of a steya-çāstra. In the story of Maṇḍiya,[19] another of Devendra's stories, Mūladeva, after he has become king of Beṇṇāyaḍa, figures as a resourceful thief-catcher (à la Haroun-al-Rashid); cf. Kathāsaritsāgara 88 and 112; Vetālapañcaviṅçati 14 (Çivadāsa 13). As a corollary to his artistry in this science we may regard the statement that he was an adept in cipher. This is also one of the necessary qualifications of the great Hindu Macchiavelli, the celebrated Cāṇakya, Minister of king Candragupta, who like Richard III, was born with teeth in his mouth.[20] Cāṇakya goes by the nick-name Kāuṭilya, *i. e.*, "Crooks."[21] The recent publication of his Arthaçāstra, or "Science of Politics" is one of the important events of Indology.

Mūladeva is, furthermore, a great magician. In Devendra's story he slaps a hunch-backed female slave upon the back, and, presto, she becomes straight. Particularly he has always at his hands one of those magic pills.[22] They are familiar in Devendra's stories; in the

[18] In Weber's Catalog of the Royal Library in Berlin, vol. I, p. 306, Mūladeva is mentioned in a series of authors on personal toilet: snānīya-sugandhisamuddeçaḥ . . . mukhavāsasamuddeçaḥ . . . sarvottamasāurabhya-samuddeçaḥ, and so on.

[19] See Jacobi, "Ausgewählte Erzählungen," p. 65.

[20] Teeth hadst thou in thy head when thou wast born, to signify thou camest to bite the world. Henry VI.

[21] Cf. Daçakumāracarita 1 (end); Çukasaptati 3 (where Kuṭila is the name of a rogue).

[22] Gulikā, guḍikā, guṭikā; in Vetālapañcaviṅçati 14 (Civadāsa's version) siddhaguṭikā; in Bṛhatkathāmañjarī 9. 743, yogaguṭikā (correct); ibid., 9. 731,

story of Mūladeva our hero thus transforms himself into a dwarf. All sorts of devices for such transformations are familiar in Hindu fiction; see especially Kathākoça, pp. 103, 110, 114, 130, 135, 184; Kathāsaritsāgara 37 and 74 (cf. Tawney, II, p. 632); Prabandhacintāmaṇi, p. 106; Meyer's Translation of Daçakumāracarita, p. 83.

The dramatic, or almost tragic note in Mūladeva's character is his love for gambling. In the story digested above the boy, on arriving in Ujjayinī, finds his father duly engaged in gambling in the gambling-hall, just as the theft of the bedstead is a jibe on Mūladeva's reputation as master-thief. In Samayāmātṛkā 6.29 Mūladeva is said to be skilled in the practices of the demon Kali, meaning that he is a gambler. Devendra's story begins by telling that his father drove him from home on account of this passion of his. In the same story he, like Yudhiṣṭhira or Nala, loses his all by gambling; in consequence he is humiliated by a rival, and is driven from the side of his beloved, the hetæra Devadattā.[23]

It is a curious, yet rational trait of story tradition that an outside atmosphere of complacency or benignity surrounds the scape-grace shape of Mūladeva. The story-tellers all like him. Don Giovanni must go to perdition in the end, but, as long as he lives, he is too entertaining to be read out of stage or drawing-room. It is true that one solemn Jain text, the Jñātādhyāyana 19, cites him, or what amounts to the same, his companion Kaṇḍarīka, as a forbidding example of sensuality.[24] Yet there is no mistaking that he is beloved of the romancer. And so it has come to pass that this dissolute rogue and companion of the base, this "Schlaumeier and Erzspitzbube," as Jacobi once designated him, is done over into a real pious hero by another Jain writer, Devendra, the author of the Vṛtti to the Uttarādhyāyana. We are accustomed to an important difference in the handling of fiction by Brahmanical texts on the one hand and Buddhist and Jinist texts on the other. Brahmanical fiction is essentially secular, tho it is employed sententiously to illustrate both the

yogaghaṭikā or yogāñgulikā (both corrupt); in Sāmavidhāna-Brāhmaṇa 3. 4. 3, golikā. See above, and Jacobi, "Ausgewählte Erzählungen," p. 9, line 38; 10, line 1; 31, lines 29–33.

[23] See below, p. 641.

[24] See Leumann, WZKM. vi. 43.

utilitarian and moral aspects of life (artha, kāuṭilya, nīti, dharma). But the Buddhist and Jinist texts are religious forthright; they teach the high piety, the high moral law, the dhamma. Yet they work up the same variegated, unmoral, often immoral fiction, and that, too, always under the cloak of teaching the law (dhammakathā, dhammakahā). The texts are full of curious discrepancies between the tissue of the story which is often palpably phlogistic, so to say, if not prurient, and the sententious piety which hangs from it as loose embroidery. It comes as a shock when we read in Aṇḍabhūta-Jātaka, how a king who is the future Buddha hires a professional rascal (dhutta) to corrupt an innocent young girl by pander's tricks worthy of the doctrines of the Kuṭṭanīmata or Samayāmāṭṛkā, in order that he may beat his own chaplain (purohita) at gambling. The text has in mind to bring out in strongest relief the mental superiority of the Buddha, but at what cost? It is hard to shut out the impression that those good saints, those Bhikkhus and Arhats; those Sāhus and Kevalins liked a romantic, or even salacious story for its own sake; that they sat there in their vihāras and āçramas with something very like the ghost of a smirk on their faces listening to what people will always listen to, but saving their faces in the end by drawing the moral which tacks itself gratuitously to the heels of almost any naughty entertainment.

The story of Mūladeva, as told by Devendra, is a *tour-de-force* of this sort, which is hard to beat and not quite easy to understand. Mūladeva is still the gambler who gambles away the clothes off his back; the black-art practitioner; the musician; the companion of low women; the *viveur;* and the resourceful adventurer. None of these qualities, we must note, respond to the Jinistic ideal. But the story recoins many of these values; it makes him out a veritable pattern and exemplar: skilled in every accomplishment, versed in many arts, noble of mind, of grateful disposition, a heroic protector, virtuous, clever, and gifted with beauty, grace, and youth. Or, in the words of Devadattā, the hetæra, whose devotion to him is the saving motif of the story: "he is wise, of noble soul, a very ocean of kindliness, skilled in the arts, pleasant of speech, grateful, virtuous, and of discerning mind." One is surprised at hearing the jargon of the

Hindu counsel of perfection—this is about what it amounts to—on such a stage and from such mouths. The way these people declaim on, and really seem honestly to admire "virtue," fits vice-crusaders better than denizens of the lower world. Aside from this paradox the happenings of the story, event by event, are sheer romance, strangely uncongenial to an Acta Sanctorum.

The purpose of the Jinist writer is served thus: Mūladeva's fortunes sink to a very low ebb indeed, because of his passion for gambling, and the rivalry of a rich suitor for the favor of Devadattā, named Ayala. In the end he manages by dint of a frankly selfish act of piety to obtain success through the favor of the gods. He gives his own scant food, which he has just obtained by begging, to a saintly ascetic who has come to a certain village, in order to break a month's fast. In consequence thereof he obtains the kingship of Beṇṇāyaḍa. The point is, that it pays to serve holy ascetics. I must say, I like Devendra, the story-teller, better than Devendra, the theologian.

Something needs to be said about the remaining characters of this story. The heroine, Devadattā,[25] belongs to the type of the beautiful and noble hetæra, gifted with every grace of heart and mind. Howsoever difficult we may find it to adjust this conception to our ideas, the fact is that with the Hindus this is a settled conception, and a settled type in fiction. The system of the erotic books deals with various grades of hetæras; the first grade, called gaṇikā, standing for the type of noble hetæra.[26] We need not try the hopeless task of appreciating such distinctions. Taken in bulk they are in the main the product of the naive schematism of the Hindu mind. Yet there is an appreciable sediment of reality as regards the beginning and end of the classification: there are vile and noble hetæras. For an extreme example of the former class see the parallel stories, Kathāsaritsāgara 58; Kathākoça, p. 128 ff.; Kalāvilāsa (Meyer's

[25] A commentator of Subandhu's Vāsavadattā substitutes the name Nagaramaṇḍanā, stating that a hetæra of that name was captivated by Mūladeva's superior intellectual qualities. See Weber, "Indische Streifen," I., 383, note 2.

[26] See Schmidt, "Beiträge zur Indischen Erotik," pp. 278 ff., 788 ff.; Meyer, Daçakumāracarita, p. 41 ff.; Samayāmātṛkā, pp. ix ff.; Çukasaptati 45.

Samayāmātṛkā, p. L ff.) As regards the noble hetæra the classical figures of Aspasia, or Phryne, or Laïs, those "companions" of antique swell society, come easily to mind as parallels, but parallels may run on different planes. The character of the Hindu hetæra is at times really noble. Such a hetæra, Vasantatilakā, is the friend of the princess Ratnamañjarī, in Kathākoça, p. 151; another one, Kuberasenā, shows the greatest devotion to her children, in Pariçiṣṭaparvan 2. 225 ff.; a third one is remarkable for her intellect in Prabandhacintāmaṇi, p. 67.

The story of king Vikramāditya and Madanamālā, Kathāsaritsāgara 38, is a story of a hetæra's true devotion which winds up with the reflection: "Thus, king, even hetæras are occasionally of noble character, and as faithful to kings as their own wives, much more than matrons of high birth." Accordingly, Prabandhacintāmaṇi, p. 116, describes the hetæra Cāulādevī as a famous vessel of beauty and good faith, excelling even matrons of good family. But the high standing of courtezans, as well as their nobility of character, is illustrated best by Vasantasenā, the famous heroine of the "Toy-Cart." She loves the Brahman merchant Cārudatta, who has impoverished himself by liberality, and ultimately becomes his wife. In our story Devadattā rivals Vasantasenā in tone and character, and yet she is a courtezan with a villainous "Mama" to guide and browbeat her, and otherwise surrounded with all the animate and inanimate real properties of her vocation. The description of the Mama, as given in Samayāmātṛkā and Kuṭṭanīmatam, shall not blacken these pages,[27] but I may draw attention, as one of the gems of our romance, to the symbolic debate between the Mama and Devadattā which contrasts the former's sordidness with the latter's refinement.

In the legend at large Mūladeva is in the habit of training with a friend, or boon companion. Mention has been made above (p. 622) of one Kaṇḍarīa (Skt. Kaṇḍarīka), but Kaṇḍarīka belong rather to the Bambhadatta cycle of stories, as one name (the other is Varadhaṇu, or Varadhaṇuga) of the *fidus Achates* of the adventurous prince Bambhadatta.[28] In the Bṛhat-kathā books (Kathāsaritsāgara

[27] Cf. the doings of Daṅṣṭrākarālā and Dhūrtāmāyā in Çukasaptati 22 and 23.

[28] Cf. Leumann, WZKU. vi. 43.

and Bṛhatkathāmañjarī) the name of Mūladeva's companion is Çaçin. The commentator Bālakṛṣṇa, to Bāṇa's Kādambarī, 19.16 (Peterson's edition), alludes to him as çaça "Hare."[29] This Çaçin, a sort of Leporello to Mūladeva's Don Giovanni, flits across the Mūladeva legend with tantalizing elusiveness: we should like to know more of him. It is rather curious that Devendra's novelette fails to mention him. But I think that he is, after all, there by reflection. When Mūladeva is driven out of Ujjenī by the Mama's machinations, he starts without a penny to bless himself with for Beṇṇāyada, where he ultimately becomes king. On the way he comes to an extensive forest. At the sight of it he reflects that, "if he could meet some other person traveling in the same direction, so that he might at least have someone to talk to, the journey through might be pleasant enough." Opportunely there comes along a Ḍhakka-Brahman, which I take to mean a "Brahman of the Thugs."[30] In his company Mūladeva crosses the forest. There is regularly a touch of facetiousness in this road-companionship, but this time the joke is rather on Mūladeva. For three days they travel together. Mūladeva has nothing to eat, whereas the Ḍhakka has a well-provisioned knapsack. At each meal-time the Ḍhakka feasts without offering Mūladeva anything, until the time comes for parting. They exchange names and addresses, and Mūladeva, tho treated thus shabbily, expresses his gratitude for the companionship. Later on, when he has become king Vikrama, he presents the Ḍhakka with a village. The curious anecdote seems to me to reflect the companion of Mūladeva, and to serve the additional purpose of placing in strong relief the grateful disposition which the story explicitly ascribes to Mūladeva.

The Jaina story of Mūlaḍeva in Māhārāṣṭrī Prākrit, by the Jaina chronicler Devendra,[31] gathers up the adventures and unfolds the

[29] The same authority mentions also Acala (Ayala), Mūladeva's rival, as one of his friends. Also a personage by the name of Vipula, otherwise unheard of in the story: Karṇīsutaḥ Karaṭakaḥ steyaçāstrapravartakaḥ tasyākhyātāu sakhāyāu dvāu Vipula-Acalasamjñitāu Caçaç ca mantripravaraḥ.

[30] See the note below, p. 641.

[31] Edited by Jacobi, "Ausgewählte Erzählungen in Māhārāṣṭrī," pp. 56–65; elaborated, or translated by Pavolini, "Vicende del Tipo di Mūladeva,"

character of this singular personage more completely and consistently than all the rest of the data which occur scatteringly in the remaining literature. It is a legendary biography without any real historical value. There certainly existed at some time or another an author Mūladeva, the son of the woman Karṇī (or Goṇī), skilled in the *ars amatoria* and kindred topics. But this connected quasi-biography, well-knit and consistent, a rattling good story, so to speak, reveals itself on closer inspection as both legendary and unoriginal. The individual items of the story are for the most part recurrent motifs from earlier sources. Devendra's skill lies in his power to connect and to imbue with life the separate members of his story. The shifting, flitting, shadowy figure of Mūladeva shapes itself into a real person in his hands. Devadattā, in whom is embalmed the notion of the noble hetæra, becomes, whether we will or not, a personage altogether lovable. The Mama makes us forget her own baseness by the sheer force of her character and the wit of her utterances. Her sayings and doings are, perhaps, the best and most original feature of the story. Mūladeva's rival, Ayala, is well delineated. Mūladeva's mishaps, the manner in which he prepares for greatness, his dream of kingship, and his choice as king of Beṇṇāyaḍa are well told. The entire setting of the story, from the moment that Mūladeva arrives in Ujjenī and becomes acquainted with Devadattā, betrays the practised skill of a good dramatist, and reveals Devendra as more than a rival of the best Jātaka-narrators. In the following translation the parallels to the individual items are stated in the notes, without, however, going into the details of comparison. For the materials involved in these comparisons, as indeed for the data involved in this essay as a whole, I am indebted in part to the essays or translations of the scholars mentioned in the foot-note on p. 632. Jacobi's excellent edition of Devendra's stories with vocabulary has long been an Indological classic.

Giornale della Società Asiatica Italiana, IX. 175 ff.; by Charpentier, "Paccekabuddhageschichten" (Upsala, 1908), pp. 57 ff.; and by John Jacob Meyer, "Hindu Tales" (London, 1909), pp. 193 ff.

THE ADVENTURES OF MŪLADEVA AS TOLD BY DEVENDRA.

There is a city called Ujjenī. A certain Rajput, Mūladeva by name,[32] had been cast out by his father because he was addicted to the vice of gambling,[33] and after roaming over the earth had come to this city from Pāṭaliputta. He was withal skilled in every art; versed in many sciences; of noble mind; of grateful disposition; a hero to those who sought his protection; devoted to virtue; courteous; clever; and gifted with beauty, grace, and youth. In Ujjenī he changed his appearance by virtue of a magic pill,[34] took on the shape of a dwarf, and astonished the city folk by his many stories, by his skill in music and other arts, and by the performance of sundry jugglers' tricks, so that he became a celebrity.

Now there lived at that time in Ujjenī a most elegant courtezan, Devadattā by name, proud of her beauty, charm, and intellect. Mūladeva heard that her pride was such that she took no pleasure in any ordinary mortal. He became curious, and, in order to stir her emotions, stationed himself at daybreak near her house, and began to intone a sweet-sounding melody. His voice vibrated with its many modulations; his song was exquisite in the harmony of its various sounds. Devadattā heard it and thought: "Ah, what an incomparable voice; this must be a god, not a mere man!"[35] She sent out her slave-girls to look for him, and, when they found him, they saw that Mūladeva had the shape of a dwarf, all of which they reported to Devadattā. She then dispatched a hunchbacked slave, Māhavā by name, to call him. Māhavā went up to him, and addressed him politely: "Very noble sir, my mistress Devadattā bids thee favor her with a visit to our house."

Mūladeva slily disguised his purpose, and answered her: "I have

[32] The part of the story beginning here, up to the point where Mūladeva is disgraced by Ayala, is essentially the same as the story of Lohajañgha, Kathāsaritsāgara 12. 78 ff.; see the notes in Tawney's Translation, vol. I., p. 574.

[33] Cf. Kathasāritsāgara 121.

[34] See above, p. 627.

[35] The theme of the lure of a beautiful voice recurs frequently (see Benfey's Pañcatantra i. 436 ff.): Meyer, "Hindu Tales," p. 263 ff.; Ardschi-Bordschi-Chan, second interpolation in 11th story (Jülg, Mongolische Märchen); Goontilleke, Orientalist, i. 277 ff.

no use for the society of courtezans; genteel men are forbidden to associate with dissolute women. As the poet says:[36]

"A courtezan is a most degraded person; she is worn out by countless gallants, is given over to drink and gluttony. She is soft of speech, but evil of mind: such a one is not regarded by gentles.

"Like the crest of a flame her nature is to devour; like intoxicating drink she bewilders the senses; like a razor she cuts the body; aye, like a thorn the courtezan is rued!

"Therefore I have no desire to go to her."

The slave-woman, however, beguiled his soul with many enticing expressions, insistently took him by the hand, and led him to the house. As he went he slapped her crooked back, and by virtue of his great art and magic skill, she was made straight. With astounded mind she brought him to the house, where Devadattā beheld him, a dwarf in shape, yet incomparably charming. In a daze she bade him be seated, and offered him betel.[37] Then Māhavā exhibited her restored figure, and told the whole story. Devadattā, still more amazed, began to converse in sweet and cultivated language: her heart was attracted to him. As says the poet:

"The conversation of clever men, pleasant in its courtliness, adroitly witty, delightful in its delicate sounds, that is sorcery—what use is there in magic roots!"[38]

It happened that a certain lute-player arrived there and sounded his lute. Devadattā was pleased, and exclaimed: "Bravo, Mister lutist, bravo, your skill is exquisite!" But Mūladeva said: "Ah, the Ujjenī-folk are passing clever; they know the difference between what is beautiful, and what is not beautiful." Devadattā asked: "Sir, what is wrong here?" Mūladeva replied: "The tube of the lute is unclean; the string full of flaws." She asked how he knew,

[36] These two stanzas are quoted in Sanskrit; Charpentier, *l. c.*, p. 59, suggests that they may be from a lost work by Mūladeva himself. See another description of the baseness of courtezans in Çukasaptati 23.

[37] For the use of betel in erotic practices see Schmidt, "Beiträge zur Indischen Erotik," Index, p. 945; for its character and chronology see Hörnle, "Uvāsagadasāo," Translation, p. 20, note; Speyer, "Studies about the Kathāsaritsāgara," p. 49.

[38] See Meyer's good note on this stanza, p. 195.

and he said, he would show her. The lute was handed him, and he drew a pebble from the tube, and a hair out of the string.[38] Then he put it in order and began to play. Devadattā and her attendants were transported. A she-elephant nearby which was always in the habit of roaring stood still rocking herself, with her ears down.[40] Devadattā and the lute-player in surprise thought: "Verily, he is Vissakammā (the Creator) in disguise!" Then she dismissed the lute-player with presents.

Dinner-time arrived and Devadattā ordered the massagist, so that they might both bathe. Mūladeva said: "Permit me to do your anointing."[41] Devadattā asked: "What! do you know this also?" and Mūladeva replied: "I do not know it perfectly, but I have stood in the presence of them that know." They brought campaka-oil; he proceeded to anoint; she was enchanted. And she thought: "What exceeding skill, what unexcelled touch: he must be some divine personage in disguise; ordinarily such excellence does not reside in a person of such shape. I must make him disclose his true shape!" She fell at his feet, and said: "Noble Sir, your unparalleled virtues of themselves mark you as a superior person. Such a one is gracious to those who appeal to him, and anxious to oblige. Show me therefore your true self, my heart longs greatly to see you!" When she kept on importuning, Mūladeva, laughing softly, removed the magic pill which had changed him, and assumed his true form. He appeared resplendent as the sun, like the God of Love bewildering all creatures by his beauty, his body abounding in

[39] Marvelous skill in detecting flaws in objects that are supposed to be perfect, Suppāraka-Jātaka, first part. Cf. the four wonderful house-servants of King Jitāri, Weber, "Handschriften-Verzeichniss," Vol. II., p. 1093, bottom; or the skill tricks in Pariçiṣṭaparvan 8. 170 ff.; Prabandhacintāmaṇi, p. 45.

[40] In Kathākoça, p. 65 ff., occurs a tourney of lute-players for the hand of princess Gandharvadattā: the music of the first quiets a mad elephant; that of the second makes a tree burst into blossom; that of the third attracts a distant deer; that of the fourth makes an elephant give up a half devoured sweet; and, finally, a fifth soothes the entire assembly to sleep. In Prabandhacintāmaṇi, p. 122, the musician Solāka sings so that a dry branch bursts forth into buds. In Kathāsaritsāgara 11 King Udayana subdues evermore with his lute wild elephants, and taming them brings them home.

[41] One of the sixty-four accomplishments (kalā) of the typical man of the world (nāyaka). See Schmidt, "Beiträge," p. 143.

fresh youth and grace. The hair on Devadattā's body stood erect with joy;[42] she again fell at his feet, and said, "You have shown me great favor!"

Then she anointed him with her own hands, and they both bathed and feasted in great state. She had him dressed in a robe fit for a god, and they passed the time in genteel conversation. Finally she said: "Noble Sir, excepting yourself, my heart has never inclined to any man. As has been truly said:

"'Whom may not one see with one's eyes, and with whom may not one hold conversation? Rare, however, is that quality in man which arouses joy in the heart.'[43]

"Therefore, to please me, you must come to this house quite constantly."

Mūladeva said: "O thou, that art devoted to virtue, an attachment to such as me, stranger that I am and poor, is not proper, nor is it likely to endure. As a rule attachments spring from self-interest alone. As the poets say:[44]

"'Birds abandon a tree whose fruit is gone; cranes a dried-up lake; bees a withered flower; and game a burnt forest.'

"'Courtezans abandon an impoverished man; servants a fallen king. Every person loves from self-interest; no one regards any other attachment.'"

Devadattā replied: "Own country or strange country are of no consequence to noble men.[45] The poet says:

"'The moon, though separated from the ocean, dwells on the head of Hara: wheresoever virtuous men go there they are carried on the head.[46] Likewise, wealth is of no consequence; noble men do

[42] Horripilation in Hindu stories is produced by joy as well as by fear; *e. g.*, Kathāsaritsāgara 10, 14, 124.

[43] According to Pavolini, GSAI. ix. 179, note, this stanza recurs in the Gāthākoça of Muṇicandrasūri.

[44] The following two stanzas are again in Sanskrit, quoted from an unknown author.

[45] This quasi proverbial statement is nullified by frequent expressions of love for home and country in Sanskrit literature; see Meyer's "Translation of Daçakumāracarita," p. 222, note.

[46] Hara (Çiva) wears the moon, whose original home is the ocean, as a diadem on his head: see Mṛcchakaṭikā (Stenzler's edition), p. 64, l. 10; Samayāmātṛkā 4. 26, 27, 29.

not attach much value to it; to virtue alone is their inclination.' Anent this it is said:

"'Speech is valued at a thousand; the rewards of love at a hundred thousand. But the devotion of a noble man exceeds a krore.'

"Therefore, by all means yield to my wishes." Then he consented, and there sprang up between them a union of surpassing love.

It came to pass that Devadattā danced before the king, while Mūladeva beat the drum. The king was delighted, granted her a boon, which she laid up in store.[47] But Mūladeva was so passionately addicted to gambling, that he did not keep even the clothes on his back. Devadattā, sweetly spoken, administered a friendly rebuke: "Dearly beloved, the passion of gambling in thee, that art the resort of all virtues, is a blemish, like the figure of the gazelle on the full-moon.[48] Gambling, as the poet says, is the foundation of every sin:[49]

"Gambling disgraces the family; is the enemy of truth; brings shame and grief upon parents and teacher. It destroys piety, and wastes property. It precludes liberality to others and own enjoyment; it steals from child and wife, from father and mother. O beloved do not adhere to this vice which makes forget God and teacher, and right and wrong; which ruins the body and leads to hell!

"Aye, by all means desist from this vice!" But Mūladeva could not control his exceeding passion.

Now there was a rich son of a merchant, Ayala by name, who had a host of friends, and was deeply smitten with Devadattā. He gave her whatever she asked; sent her clothes, jewels, and other presents. He bore Mūladeva a grudge, and sought out his vulnerable points. Mūladeva regarded Ayala with suspicion, and did not come to the house, unless there was some special occasion. Now Devadattā's "Mama"[50] said to her: "My child, drop Mūladeva! You

[47] This practice is referred to quite frequently: Kathākoça, p. 48; Prabandhacintāmaṇi, p. 77; Jātakas, Vol. I, p. 24.

[48] The Hindus fancy either a gazelle or a hare in the moon.

[49] Cf. the reflections on gambling in the gamblers' stories, Kathāsaritsāgara 121.

[50] This "Mama" is sometimes the real mother of the hetæra, but, generally speaking, rather a hired manager. See Dhanaṁjaya's Daçarūpa 2.

have no use for this penniless gallant, whereas Ayala is a stupendous giver who keeps on sending much wealth; attach yourself to him with all your soul! Two swords do not go into one scabbard, and one does not polish a non-precious stone.[51] Therefore drop this gambler!" Devadattā answered her: "I am not, my mother, bent upon money alone; to noble qualities rather is my inclination." Her mother asked of what sort were the noble qualities of that gambler, and Devadattā retorted: "Mama, he is altogether made up of virtues:

"He is wise, of noble soul, a very ocean of kindliness; skilled in the arts, pleasant of speech, grateful, devoted to virtue, and of discerning mind; therefore I shall not give him up!"

Then the mother started to convert her by means of sundry symbols: when Devadattā asked for red lac she gave it her dry; when she asked for sugar-cane she gave it her squeezed; when she asked for flowers she gave her mere stems.[52] And when pressed to explain, she said: "Of such sort is that most beloved of thine, and yet you will not give him up." But Devadattā thought that the mother was foolish in offering such illustrations.

(By way of counter-illustration) Devadattā then said to her mother: "Mama, ask Ayala for sugar-cane!" She spoke to him, whereupon he sent a cart-load. Devadattā burst out: "What, am I a she-elephant, to have sent me such a load of cane with leaves and branches?" The mother pointed out that he must surely be liberal to have sent in this wise. (Of course) Ayala had figured that Devadattā would share with others. Next day Devadattā said to Māhavī: "My dear, tell Mūladeva, Devadattā has a craving for sugar, therefore send her some!" She went and told him. Now

20; Samayāmātṛkā 1. 40 ff.; and especially 4. 9 ff. The Mama's greed for money comes out, ibid., 4. 80; her hostility to poor lovers of her charge, ibid., 5. 80 ff.

[51] The rendering of the second of these proverbs is not quite certain.

[52] These three symbols state technically how a hetæra should estimate her lover in dollars and cents. They appear to be borrowed directly from Samayāmātṛkā 5. 78: "After she (the hetæra) has sucked him (the lover) dry, and his serviceableness is at an end, she should throw him off like a squeezed stick of sugar-cane; for a withered flower disfigures the place where it has been put, and is removed from the braid of hair."

PROC. AMER. PHIL. SOC., LII, 212 W, PRINTED DEC. 16, 1913.

Mūladeva took two sticks of cane, cut them into blocks two inches in length, sprinkled them with a mixture of four spices,[53] made them fragrant a bit with camphor, and split them slightly at both ends. Then he took some fresh jessamine, covered the cane with it, packed it and sent it off.[54] Māhavī went and delivered it; then Devadattā showed it to the mother, saying: "Regard, Mama, the difference between men: this is why I am taken with these his qualities."

The mother concluded that Devadattā was hopelessly infatuated; that she would not of her own accord let go of Mūladeva; and that, therefore, she herself must find a way by which that gallant might be driven out: then all would be well. So, after reflection, she said to Ayala: "Pretend to her that you are going to another town. Then, when Mūladeva has come, do you arrive with a retinue and shame him in such a way that he will leave the place in disgrace. Then you two will be united. I shall furnish you the needed information." He agreed, and on the next day did just as he had been told. He went off, pretending that he was going to another town. Mūladeva came; Ayala was informed by the mother, and arrived with a large retinue.

Devadattā saw Ayala coming, and said to Mūladeva: "Such and such is the situation; mother has accepted money sent by him. Do you therefore for a while hide under the couch." He did so, but Ayala spied him, seated himself upon the couch, and told Devadattā to get ready all the belongings of a bath. Devadattā agreed and told him to get up and put on a robe, in order to be anointed.[55] Then Ayala said: "I saw to-day in a dream, that I would be dressed, anointed, and bathed here upon this couch; make then my dream come true." Devadattā asked whether he wished to spoil all the valuable belongings, such as coverlets and pillows, but he replied that he would give her others, more sumptuous. The Mama agreed with this; Ayala was anointed, massaged, and washed with warm bath-

[53] Cāturjāta; cf. Schmidt; "Beiträge zur Indischen Erotik," p. 850.

[54] Cf. perhaps the games called ikṣubhañjikā "breaking of sugar-cane," and navekṣubhakṣikā "feasting on fresh sugar-cane," mentioned in Schmidt, "Beiträge zur Indischen Erotik," p. 196. They belong to the accomplishments of the nāyaka, or "elegant."

[55] Cf. the dripping vesture after a bath of the heroine in Karpūramañjarī i. 27; and see Meyer's note on this passage, p. 203.

ing water right there on the couch, so that Mūladeva, who lay underneath, was drenched with it. Then Ayala's men entered, armed, and the mother gave the signal. Ayala seized Mūladeva by the hair, and said to him: "Ho there! see now if you find any one to protect you!" Mūladeva looked about him, and perceived that he was surrounded by men with sharp swords in their hands. Then he reflected: "I cannot get away from them, but I must live to retaliate for their enmity. Now I am unarmed, so this is not the time for heroic deeds." Then he said to Ayala: "Do what you please!"

Ayala observed that Mūladeva by his very carriage showed himself to be a person of distinction, and reflected that great men in the course of the revolving cycle of existences easily get into misfortune. As the poet says:

"Who in this world is always lucky, who can rely upon Fortune's favors? Who does not on occasion take a fall, aye, who is not crushed by fate?"

Then he said to Mūladeva: "Tho you have come to such a pass, do you now go free, and, if ever, by the might of fate, I should come to grief, treat me just as I have treated you!"

Then Mūladeva went from the city disspirited and sad, brooding: "See how I have been tricked by this man." He first bathed in a clear pond, and then decided to travel to a distant land, there to devise some scheme of retaliation.[56] He set out toward Beṇṇāyaḍa. After passing many villages and towns he came to the edge of a forest twelve leagues in length. It occurred to him that if he could meet some other person traveling in the same direction, so that he might at least have some one to talk to, then the journey through might be quite pleasant. After a while there approached a Ḍhakka-Brahman[57] of distinguished appearance, equipped with a sack of

[56] A sort of "Live to fight another day." See the proverbial statement to that effect, Pariçiṣṭaparvan 8. 256.

[57] The words ḍhakka, ṭhakka, ṭakka, ṭāka, Mahratti ṭhaka, are Hindu terms for a despised people, tribe, caste, or guild; see Kern, "Indische Studien," XIV. 396; Meyer, to the present passage, p. 205, note. According to Pischel, "Grammatik der Prākrit-Sprachen," § 25, a dialect called Ḍhakkī is spoken by gamblers in the second act of the Mṛcchakaṭikā. Sanskrit sthaga, "cunning, sly, fraudulent, dishonest," reported by the lexicographers, is probably the same word; cf. Sthagikā, the name of a thieving courtezan,

provisions. Mūladeva asked: "Reverend Sir, have you far to go?" He replied: "There is beyond the forest a place called Vīranihāṇa; there is where I am going. And where may you be bound for?" Mūladeva said that he was going to Beṇṇāyaḍa, and the Doctor then proposed that they should travel together. The two of them started, and, as they marched along, they saw at noon-time a clear pool. The Dhakka proposed that they should rest a while, whereupon they went to the water and washed their hands and feet. Mūladeva sat down in

Çukasaptati 7. The words most frequently imply stinginess. Mahratti ṭhaka, according to Yule, "Dictionary of Anglo-Indian Terms," is the name in that language of the notorious guild of the Thugs (see under that word), and it seems to me likely that we have in all these words the precursors in Hindu literature of the Thugs, or Phansigars, even though stinginess and roguery, rather than murderousness, are their characteristics in the literary documents referred to. According to Hörnle, Uvāsagadasāo," Appendix ii, note 8, Pāli cora-ghātaka, German "Raubmörder," is the equivalent of modern ṭhag. I add here the curiously parallel Ṭakka-anecdote from Kathāsaritsāgara 65. 140 ff.: "There lived somewhere a rich but foolish Ṭakka who was a miser. He and his wife were always eating barley-grits without salt, and he never learned the taste of any other food. Once the Creator moved him to say to his wife: 'I have conceived a desire for a milk-pudding; cook me one today.' His wife agreed, and proceeded to cook the pudding, while the Ṭakka remained indoors, concealed in bed, for fear some one should see him, and drop in on him as a guest. In the meantime a friend of his, a Ṭakka who was fond of mischief, came there, and asked his wife where her husband was. And he, lying on the bed, said to her: 'Sit down here, and remain weeping and clinging to my feet, and say to my friend: "My husband is dead." When he is gone we will comfortably consume this pudding.' After he had told her this she began to cry, and the friend came in and asked her what was the matter. She said to him: 'Look my husband is dead.' But he reflected: 'I saw her a moment ago happy enough, cooking a pudding; how comes it that her husband is now dead, tho he has had no illness? No doubt the two have arranged this trick, because they saw that I had come as a guest. So I will not go.' Thereupon the mischievous fellow sat down and began crying out, 'Alas, my friend! Alas, my friend!' Then his relations came in and prepared to take that silly Ṭakka to the burning-place, for he still continued to counterfeit death. But his wife came to him and whispered in his ear: 'Jump up, before these relation take you off to the pyre and burn you.' The foolish man answered his wife in a whisper: 'No! that will never do, for this cunning Ṭakka wishes to eat my pudding.'" The story goes on to tell that the stingy Ṭakka actually allowed himself to be burned, sacrificing his life in order to save his pudding. The story does not, as far as I can see, occur in the two sister-texts of the Kathāsaritsāgara, namely, Bṛhatkathāmañjarī and Bṛhatkathāçlokasaṁgraha.

the shade of a tree on the bank. The Ḍhakka loosened his provision-sack, put grits into a dish, moistened them with water, and fell to eating. Mūladeva thought: "This is just what you might expect from the Brahman gang, to be given over to feeding;[58] doubtless he will offer me some later on." But the Doctor, after having eaten, tied up his knapsack, and proceeded on his way. Mūladeva followed, hoping that he would give him something in the evening. Yet in the evening he ate in exactly the same way, and did not give him anything. Mūladeva proceeded, hoping that he would give him something in the morning. Night overtook them as they traveled; they stepped from the road, and slept under a banyan-tree. At daybreak they set out again; at noon they halted after the same fashion, but the Ḍhakka ate just as before, giving him nothing. On the third day Mūladeva thought that, now that the forest was almost crossed, he would surely on this day give him something. Yet even then he did not give him anything. They crossed the forest, and their roads parted. The Doctor said: "Sir, this is your road, and this is mine; depart you therefore by this." Mūladeva said: "Reverend Doctor, I have traveled with your assistance. My name is Mūladeva: if my affairs should ever prosper, then you must visit me in Beṇṇāyaḍa. What now might your name be?" The Ḍhakka said: "Saddhaḍa, but people also know me by the nick-name Nigghiṇasamma."[59] The Doctor then started for his village; Mūladeva proceeded to Beṇṇāyaḍa.

After a while he perceived a house which he entered for alms. After that he tramped through the entire village, obtaining some lentils, but nothing else. Then he started toward a pool. There shortly he perceived a mighty ascetic of great majesty, his body lean from abstinence, who was entering (the village) to break a month's fast. When Mūladeva saw him the hair on his body stood erect with joy, as he thought, "Oh, I am in luck, my fortune is made, since this

[58] A Brahman without greed is hard to find, according to Harṣacarita 6 (Bombay edition, 1897, p. 181); cf. Weber, "Indische Studien," X., 61, 62.

[59] Saddhaḍa seems to mean, ironically, something like "Pious Giver"; Nigghiṇasamma, something like "Devotee of Pitilessness."

mighty ascetic has at this juncture come within the path of my sight. For I shall certainly come into fortune:

"As the wish-tree in the Marutthalī-desert, as a shower of gold in a poor man's house, as a royal elephant in the house of a Pariah, thus here is this great-souled saint.

"Purified by insight and knowledge; intent upon the five great vows; wise; endowed with patience, gentleness, and rectitude; intent upon salvation; devoted to study, meditation, and self-mortification; pure in thought; engrossed with the five-fold samiti-virtues, and the three-fold gupti-restraints; without wordly goods; free from the attachments of house-holders—this noble person is a Sāhu (Saint).

"Such a person is a fruitful field, irrigated by the water of holy thought: wealth deposited in it as grain yields endless crops both here and in the other world.

"I must not therefore hesitate: I shall offer him these lentils. Since the village is stingy, this noble Sāhu, after having visited some houses, will come back here. But I shall make two or three trips, so as to get more; there is also another village nearby. Then I shall give him all I have gathered."

Thereupon, with reverent gestures, he offered his lentils to the Saint. The Sāhu, observing the perfection of his obeisance, understanding the pure-mindedness of this gift of his possessions, said: "O thou who art devoted to piety, let me take a little," and held out his bowl. Mūladeva's zeal increased as he gave, and the Sāhu chanted in metre (the following half of a stanza): "Verily, fortunate are the men whose lentils serve for the Sāhu's break of fast!" Then a divinity in heaven, devoted to the Saint, pleased with Mūladeva's piety, called out: "O son Mūladeva, thou hast done well! Therefore, in the second half of this stanza (recited by the Saint), ask what thou wishest: I shall grant all!" Mūladeva chanted: "The courtezan Devadattā, a thousand elephants, and a kingdom!" The divinity responded: "My son, live without care. Very shortly thou shalst obtain all this by the might of the sage's feet."[60] Mūladeva said: "O blessed divinity, thus be it!" Then he bade farewell and

[60] In Prabandhacintāmaṇi (Tawney's translation), p. 15, King Çālavāhana also owes his exalted station to the favor of an ascetic, to whom he, a poor carrier of wood, had given his barley-meal in order that he might break a month's fast.

returned (to the village). The Saint went to a grove. Mūladeva begged alms for the last time, ate and started for Beṇṇāyaḍa, where he arrived in due course.

By night he slept outside in the travelers' hospice, and in the last watch had a dream: The moon with full disc, her brilliance undimmed, entered into his body. Another tramp had the very same dream which he told to the rest of the tramps. One of them said: "You will to-day get a tremendously big cake full of ghee and sugar!" But Mūladeva did not tell his dream, thinking that they knew not its true meaning. The tramp started out for alms, did get from a house-wife such a cake as had been described, and joyously told the other tramps. Mūladeva went to some garden, where he made friends with a wreath-maker by helping him gather flowers. The gardener gave him some flowers and fruits. These he took, and, having adorned himself, went to the house of an interpreter of dreams. He paid his respects, and inquired about his prosperity and health. The teacher in turn addressed him politely, and inquired after his concerns. Mūladeva, with folded hands, narrated his dream, whereupon the teacher exclaimed joyously: "I shall interpret your dream in an auspicious hour; in the meanwhile now be my guest." Mūladeva accepted, bathed, and feasted sumptuously. After dinner the teacher said: "I have here a lovely daughter; out of regard for me do you marry her." Mūladeva said: "Father, would you make one whose family and character you do not know your son-in-law?" The teacher replied. "My son, behavior of itself betrays a man's family, even when he has not made mention of it." The poet says:[61]

"Behavior declares one's family, speech one's country; agitation betrays love; and personal appearance the food one subsists on." Moreover:

"Is it necessary to impart smell to the lotus, or sweet to sugar; or to teach sport to noble elephants, or refinement to them that have sprung from a good family"?[62] And again:

[61] This stanza in Sanskrit.

[62] See Agaḍadatta, stanza 75 (Jacobi, "Ausgewählte Erzählungen," p. 72): "Who paints the peacock, or imparts their gait to the royal swans? Who bestows fragrance upon the lotus, and good manners upon them that are sprung from noble families?"

"If virtue be present, what matters family? The virtuous have no need of family; but a yet more grievous stain on the vicious is the very stainlessness of their family."

By such and the like saws he was induced to consent and marry her in an auspicious hour. Then he was told the purport of the dream, namely, that he should be king within seven days.[63] When he heard that he was rejoiced, and stayed there happily. On the fifth day he went outside the city and sat down in the shade of a campaka-tree.

At that time the king of the city died without leaving a son. Then the five royal emblems (magic electors of a king) were consecrated.[64] After roaming about within the city they went outside, and came upon Mūladeva. He was discovered sitting in shade that did not shift.[65] On beholding him the elephant roared; the steed neighed; the water-pitcher sprinkled; the chowries fanned; and the sun-shade[66] stood over Mūladeva. Thereupon the people shouted "Hail, Hail." The elephant lifted him upon his back; he was conducted into the

[63] In Pariçiṣṭaparvan 8. 231, a pregnant woman desires to drink the moon: it is a sign that her son will become king. The sight of the moon in a dream secures to Madanarehā an imperial son, in the story of Nami, Jacobi's "Ausgewählte Erzählungen," p. 41, l. 23 ff.; Kathākoça, p. 19. There are many other dreams and signs of future royalty: In Pariçiṣṭaparvan 6. 232, the son of a courtezan by a barber dreams that Pāṭaliputra is surrounded by his entrails, whereupon he becomes king of that city. In Jagaddeva's Svapnacintāmaṇi, 1. 62, we have: "He who surrounds in his dream a city or village with his entrails as a magic instrument, becomes prince in the city, ruler of a province in the village." (Half a dozen parallel verses from other texts are quoted by von Negelein, the editor of this last text.) To be born with teeth is a sign of future kingship, Pariçiṣṭaparvan 8. 196. In Prabandhacintāmaṇi, p. 80, a three-year old prince seats himself upon the throne, and is immediately crowned king. In the same text, p. 117, a king washes the feet of a hermit, and recognizes by the upward lines on them and other signs, that the hermit is worthy of a throne.

[64] On this curious, widely prevalent magic practice see now Edgerton's paper, JAOS. xxxiii. 158 ff. The list of these five magic electors follows three lines below.

[65] This is a sign of the temporal or spiritual superiority of the person sitting in the shade. Meyer, p. 212, cites several instances from Hindu literature and elsewhere, to which add Prabandhacintāmaṇi, p. 16; Kathākoça, p. 97.

[66] puṇḍarīkaṁ sītaṁ chattram: Kṣemendra's Lokaprakāça, i. 15 ("Indische Studien," XVIII. 327).

city, and consecrated king by ministers and vassals. The divinity then appeared on the firmament of the heavens, and proclaimed: "Behold, behold, this is the puissant king Vikkama, expert in all arts; his body is permeated with divinity! Therefore, him that does not do his bidding I shall not spare." Then the entire retinue of vassals, ministers, chaplains, and others became submissive to his commands. Mūladeva lived in the enjoyment of refined pleasures of the senses. Shortly he entered into relations with Viyāradhavala, the king of Ujjenī, and they became united in close mutual friendship.

While this was going on Devadattā, after she had witnessed Mūladeva's humiliation, became exceedingly wroth against Ayala. She upbraided him: "See here, I am a courtezan, and not your wedded wife,[67] and yet you behave thus in my house: now you need not trouble yourself about me any further!" Then she went before the king, fell at his feet, and said: "Grant me the favor of that gift (which I have reserved for myself)!"[68] The king said: "Speak out, the favor is already thine; what more have you to say?" Devadattā said: "Your Majesty, I desire that no man other than Mūladeva be bidden to me, and that Ayala be forbidden to come to my house." The king said: "It shall be as you please, but tell me now, what is this affair of yours?" Then Māhavī stated the case. The king became incensed against Ayala, and said, "How now, in this my city are these two jewels, and even these this fellow does maltreat!" He had him brought up and beaten; then he said to him: "Sirrah, are you king here, that you demean yourself thus? Therefore do you now seek protection, else I shall hold your life forfeit!" Devadattā said: "My lord, what purpose is served by killing him, dog as he is in the main:[69] let him go!" The king said: "Sirrah, I am going now to release you on the word of this noble woman, but

[67] See the story, Kathākoça, p. 187, of the leper husband, as illustrating by an extreme example the devotion of a wife. In Daçakumāracarita 6 (Mitragupta's third story) we read: "Husbands are the only divinities of wives, especially of wives of good family." In Kathāsaritsāgara 13, end: "Thus, O queen, women of good family, ever worship their husbands with chaste and resolute behavior."

[68] See above, p. 638.

[69] Or, "dog-foot," as he is. In Kathāsaritsāgara 13 a dog-foot is branded on the forehead as a sign of disgrace.

you shall obtain full pardon only when you have produced Mūladeva himself." Ayala fell at his feet and went out of the palace. He began to search in every direction, but even so he did not find him. Then on the full-moon of this very month[70] he loaded ships with wares and started for Persia.

In the meantime Mūladeva sent a letter and presents to Devadattā and to king Viyāradhavala. To the king he wrote: "I am greatly attached to this Devadattā; therefore, if it so pleases her, and if it is agreeable to you, kindly send her to me." The king said to his royal wardens: "I say, why has king Vikkama sent such a letter; is there any difference between him and me? Even this my entire kingdom belongs to him, how much more Devadattā: let her, however, state her own wishes!" Devadattā was called; the matter was explained to her, and she was permitted, if she so liked, to go to him. She said: "It is very gracious of you to permit me my heart's desire." Then the king honored her with presents of great value, and she was dispatched to Mūladeva who received her in greatest state. They ruled the kingdom in common, and Mūladeva lived with her, enjoying his love, but even more engrossed with building Jina temples and images, and doing honor to the Saints.

Now Ayala, who, in the course of his tour through Persia, had amassed great wealth and choice wares, arrived at Beṇṇāyaḍa, camping without the city. He asked the people the name of the king there, and was told, king Vikkama. Then he filled a dish with coined and uncoined gold and pearls, and went on a visit to the king. The king had a seat offered him; as soon as he was seated he recognized Ayala, but Ayala did not recognize the king. The king asked: "Whence has the merchant come?" And Ayala said, from Persia. On being honored by the king Ayala proposed: "Your majesty, send some inspector to appraise my wares." Whereupon the king said that he would go in person. The king went with a revenue officer,[71] and was shown the wares on the ships, consisting of mother-of-pearl, betel, sandal-wood, aloes, madder, and so on. In the

[70] tīe ceva ūṇimāe. Thus Jacobi's uncertain conjecture; Meyer, p. 215, note, "one account of this very deficiency." He does not state his authority.

[71] pañcaula = Skt. pañcakula: see Prabandhacintāmaṇi, pp, 18, note, and 84, and especially p. 208.

presence of the appraiser the king asked: "Look here, Mr. Merchant, is this the extent of your property?" Ayala answered: "Your majesty, it amounts to just so much." The king then ordered: "Make the merchant give half, but weigh in my presence!" The goods were weighed in bulk. By noticing their (unexpected) weight, by pushing against them with the feet, and by poking into them with a spike, valuables were found hidden within the madder[72] and the other bales. The king had the bales ripped open; a careful search revealed just where was the gold and the silver, and where the many other precious wares, such as crystals, pearls, and corals. The king, in anger, ordered his attendants: "Zounds, chain this convicted thief!" They chained Ayala, his heart beating. The king committed him to the hands of the guards, and returned to the palace.

The chief of the guards led him into the king's presence. And when the king saw him securely bound, he ordered his immediate release. Then he asked Ayala: "Do you know me?" Ayala said: "Who should not know the great princes that are famed over the whole earth?" The king said: "A truce to your flattery; say straightforth whether you know me!" Then Ayala said: "Your Majesty, I do not know you at all." Thereupon the king had Devadattā called; she appeared like a lovely Apsaras, wearing jewels on all her limbs. Ayala recognized her, and was mightily ashamed in his soul. And she said: "Behold this is that Mūladeva to whom you said at that time: 'Show thou courtesy to me also, if ever, by the might of fate, I should come to grief!' There lies your chance: now that you have gotten into danger to property and life, you are freed by the king who is kind to the humble and afflicted!" Upon hearing this he said, abashed in his soul: "Your mercy is great!" He fell at the feet of the king and of Devadattā. Then he addressed himself to the king: "I did at that time obscure Your Majesty who makes all people happy, who is adorned with every accomplishment,

[72] A curious parallel to this touch in the story occurs in Prabandhacintāmaṇi, p. 105. A young merchant "bought some sacks of madder, and, when he came to sell them, he saw some spoons of gold that had been hidden in them by merchants for fear of thieves." This text is acquainted with the Uttarādhyāyana literature in general; see p. 98.

just as Rāhu[73] obscures the ful-moon, spotless by nature: may Your Majesty pardon me that! Moreover, the king of Ujjenī, angry because I have abused you, does not allow me to enter that city." The king said: "You are already pardoned by the mercy of the queen." Ayala with great devotion again fell at their feet. Devadattā had him bathed and dressed in a robe of price, and the king remitted his duties. He was sent to Ujjenī, and Viyāradhavala, at the request of Mūladeva, pardoned him.

Nigghiṇasamma, too, having heard that Mūladeva had entered upon his kingdom, came to Beṇṇāyaḍa, and obtained an audience. The king, in a spirit of piety, presented him with the village he came from. He bowed in gratitude for the great favor and returned to the village.

At this time the tramp heard that Mūladeva had seen the same dream as himself, but that he had become king in consequence of his ardent desire. Now he thought: "I shall go where there is milk to be gotten. That I shall drink and sleep until I shall again see that dream."—As to whether he shall see it no man reporteth.

[73] The demon of eclipse.

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OBITUARY NOTICES
OF MEMBERS DECEASED.

WILLIAM WATSON GOODWIN.

(Read January 3, 1913.)

William Watson Goodwin, a member of the American Philosophical Society since 1895, was born May 9, 1831, at Concord, Mass., and died June 15, 1912, at Cambridge. For fifty-six years he stood in some official connection with Harvard College. A graduate of the class of 1851, he was tutor in Greek and Latin from 1856 to 1857, tutor in Greek from 1857 to 1860, from 1860 to 1901 Eliot professor of Greek literature, from 1901 to 1912 professor emeritus, and from 1903 to 1909 overseer of the university. Even after his resignation of the Eliot professorship in 1901, his zeal did not permit him to remain inactive, and for seven years his colleagues gladly accepted his offer to continue his course on Plato and Aristotle.

In the history of education in America few men have exceeded Goodwin's period of service; and few have conferred greater distinction on American scholarship. His life is no exception to the rule that the annals of a scholar's career are short and simple. His many years were spent in unremitting and unobtrusive labor for the welfare of Harvard in a period fruitful in far-reaching changes, a period that witnessed at one end the decline of the old type of American college, and at the other the growth of the American university. He was clear-sighted in his judgment and temperate in his reasoning alike when he advocated, or when he opposed, the policies that shaped the conduct of Harvard University to its present estate.

But it is as an Hellenist that his name will live, for directly and indirectly as an interpreter of the literature and language of ancient Greece, he had a large influence on the temper and conscience of classical scholarship in the United States.

In the middle of the last century our native classical scholarship had scarcely awakened to the possibility of the independence born of original research. A leisurely interest in the classics as the humanities, a somewhat torpid belief in their efficiency as a discipline for all

mental dispositions, which was tempered but rarely by incursions into the larger meanings of Hellenic literature, sufficed with but rare exceptions for the generation under which Goodwin grew to manhood. In the year when, at the age of twenty-nine, he succeeded Felton in the Eliot professorship, Goodwin gave evidence with a certain brilliant audacity that he severed himself from the past. The year 1860 may well be taken as the mark of the appearance of a new spirit in our classical scholarship. In that year Hadley at Yale published his "Greek Grammar" based on the work of Georg Curtius; at Harvard, Goodwin brought out the book with which his name will be longest associated—the "Syntax of the Moods and Tenses of the Greek Verb."

I cannot discover that Goodwin had occupied himself especially with the problems of systematic Greek grammar in any of its aspects during his residence at the universities of Göttingen, Bonn, and Berlin; but the "Moods and Tenses" is itself a witness to the quickening spirit exercised by European masters upon the American philologists who, about the middle of the last century, began to cross the ocean in search of the inspiration they could not find at home. Yet the work, alike in its first form and when rewritten and greatly enlarged thirty years afterwards, owes relatively little to European research for its essential distinction. Not that Goodwin was not indebted, as he himself gladly acknowledged, to the labors of the great Danish scholar Madvig, or that some of his positions had not already been occupied by German syntacticians. But at the very outset of his career he had learned to think for himself—"Librum aperi, ut discas quid alii cogitaverint; librum claude, ut ipse cogites." It was due to his native and trained sense and knowledge of language as the instrument of the most delicate and refined expression that he was enabled to safeguard the subject of the modal and temporal relations of the Greek verb from the twofold danger that menaced it at the time. On the one hand, metaphysical subtlety exercised a malign influence in disturbing a clear understanding of the facts and their interpretation; on the other hand, comparative grammar, a science at that time in its infancy, by the very width of its horizon and the insecurity of its basis, threatened to carry back to the primi-

tive home of the Aryans many of the problems that pertained in the first instance to the history of the Greek language on Greek soil.

It was Goodwin's clarity of judgment—with characteristic modesty he called it "common sense"—that saw the truth when the Germans had generally failed to release themselves from the intricacies of philosophical abstractions; and with equal sagacity and discernment he refused to trust himself upon the shifting sands of comparative syntax. The metaphysical syntax that held sway when Goodwin began his career is a thing of the past; but historical syntax, both in the wider area of the Indo-European languages and on Greek territory, has immeasurably increased its influence as it has steadily built upon securer foundations.

The wonder is that after thirty years the large increments of science should have found themselves easily at home and should have worked no disturbance to the principles laid down in a book, of which its author, in his revision of 1890, said that it had appeared "in the enthusiasm of youth as an ephemeral production." The truth is that the "Moods and Tenses" of 1890 is at bottom the "Moods and Tenses" of 1860; for, though there was much to add to a work designed to fill a larger compass, there was astonishingly little to curtail, to modify in important particulars, or to reject outright. I know of no book of like complexion which possesses the quality of prescience in equal degree. The "Moods and Tenses" displays the working of an independent and resourceful thinker, who with steadied purpose aimed at presenting the essential facts, freed from the entanglements of specious and shifting theories. To its judicious presentation of these facts, to its lucidity and precision of statement, perhaps even to its very refusal to enter at all points and at all hazards upon the treacherous ground of absolute definition, the book owes its fame as a standard work, still indispensable, despite the subsequent mass of treatises, both large and small, that traverse the whole or some part of the same field. And it has had a wider and more salutary influence than any American or English book in its province for more than half a century.

Apart from its virtues of lucidity and orderliness, there are certain special features of the "Moods and Tenses" that have com-

manded most attention: the distinction between the time of an action and the character of an action, the distinction between absolute and relative time, the division of conditional sentences (and in particular the treatment of *shall* and *will* and *should* and *would* conditions, which Goodwin discussed at some length in the *Transactions of the American Philological Association*, Vol. 7 (1876), and in the *Journal of Philology*, Vol. 8 (1879)), the relation of the optative to the subjunctive and other moods, and the origin of the construction of οὐ μή with the subjunctive and the future indicative.

The author of the "Moods and Tenses," the *doctor irrefragabilis* of Greek syntax, would have been the last to claim that he had, with Browning's grammarian, settled all of the "ὅτι's business." He had not been, like Tom Steady in "The Idler," "a vehement assertor of uncontroverted truths; and by keeping himself out of the reach of contradiction, had acquired all the confidence which the consciousness of irresistible abilities could have given." There is much in Greek syntax that is debatable territory; but whenever Goodwin entered that territory—though he was not a statistician, as the earlier great scholars were not—his prevailing soundness of judgment and his range of illustration afford the controversialist only rarely the luxury of holding a different opinion.

Goodwin's "Greek Grammar" appeared ten years after the "Moods and Tenses," and inherited as by right the distinction and the distinctive features of the earlier work. The "Moods and Tenses" appealed to the advanced student and the teacher; the "Grammar" brought before the neophyte the facts of the language in exact and clear form; and showed that its author possessed the rare (and often underestimated) faculty of making a good elementary book. Only he who has himself labored to improve on Goodwin can adequately realize the clarity and compactness of his statements that never err through undue emphasis either on logical or on æsthetic relations.

The very excellence and success of Goodwin's work in the department of grammar made the wider public, and to a certain degree even the Hellenists of this country, ignorant of the scope and the distinction of his work in other fields. It is an altogether erroneous notion that Goodwin was purely a grammarian, honorable as

that title has been made by many illustrious scholars. The range of his sympathies with Greek literature was indicated early in his career. The Greek grammar appeared in 1870; in the same year was published Goodwin's revision, in five volumes, of the translation of Plutarch's "Morals" made by various hands in the seventeenth century. Innumerable errors and infelicities of the old translation were cleared away by Goodwin, whose work was termed a "vindication" of Plutarch by Emerson, who contributed an Introduction to the revision. English readers who would acquaint themselves with the deep and broad humanity of the sage of Chæronea, in whom the intellect was illuminated by the force of morals, will long continue to use the translation of the Cambridge scholar.

With Greek philosophy Goodwin never claimed the intimate acquaintance of the professional philosopher. The temper of his mind was not metaphysical. Yet he had a large knowledge of the great ethical books of Greek literature, and years of close study made him a wise and judicious interpreter of the "Republic" of Plato and of Aristotle's "Ethics." To the investigation of the history, antiquities, and law of ancient Greece he brought a mind keenly observant of the similarities and differences between ancient and modern times. It is in the interpretation of the masterpiece of Greek oratory that the scholar must be able to draw, in well-nigh equal measure, upon a sound knowledge of ancient history and ancient law. Goodwin's mastery of this double field appears in his editions of Demosthenes' "On the Crown" (1901) and "Against Midias" (1906). He wrote also on "The Relation of the πρόεδροι to the πρυτάνεις in the Athenian Senate" (*Transactions of the American Philological Association*, Vol. 16, 1885), and on "The Value of the Attic Talent in Modern Money" (*o. c.* Vol. 16).

It is to be regretted that Goodwin would not allow himself to be persuaded to give to the world an edition of Æschylus, to the interpretation of whose text he devoted years of profound study. He edited the text and prepared a translation of the "Agamemnon," to be used in connection with the public presentation of that play by the Department of Classics at Harvard in 1906. Of his critical method we have a luminous example in the paper entitled "On the

Text and Interpretation of certain passages in the Agamemnon of Æschylus" (*Transactions Amer. Philol. Assoc.*, Vol. 8, 1877). In confronting the great difficulties of the text of Æschylus, Goodwin was invariably hostile to the sciolist who complacently substitutes his emendations for the words of the poet. "Est quaedam etiam nesciendi ars et scientia"—an admonition applied far more rigorously by the American scholar than by its German author.

In common with many men of his position Goodwin turned at times to editorial work of a humbler character. He reëdited Felton's editions of Isocrates' "Panegyricus" (1863) and the "Birds" (1868) and "Clouds" (1870) of Aristophanes. One of the most excellent books of its kind is the "Greek Reader" (1877, and in many later editions), while his edition of the "Anabasis" (1885 ff.), prepared in conjunction with one of his colleagues, Professor J. W. White, is a model for its exact attention to grammatical details.

It was Goodwin's good fortune to visit Greece as a young man when fresh from his studies in Germany; and it was he who was the first director of the American School of Classical Studies at Athens (1882–83), an appropriate honor for the foremost Greek scholar of his time who was also one of the founders of the American Institute of Archæology. To his acquaintance with the land of Greece, reinforcing his knowledge of Greek literature and history, we owe the admirable paper on "The Battle of Salamis," first published in 1885 and in another form in 1906. Goodwin's careful sifting of the evidence determined the several localities in question and convincingly described the dispositions and movements of the Greek and barbarian forces in connection with that memorable contest. His interest in the land of Greece was fittingly signalized by his being named a knight of the Greek Order of the Redeemer.

Such are the landmarks in the career of a scholar whose life was spent in quiet devotion to high things, a life that made no parade and sought none of the noisy ways of fame. Yet to few Americans of our time has been given an ampler measure of the tribute of recognition that great powers have been used effectively and serviceably. Goodwin's mastery of Greek syntax enfranchised in Great Britain the Hellenic scholarship of the United States. The "Moods

and Tenses" became there, as at home, a standard treatise; the *Journal of Philology* and Liddell and Scott's Greek Lexicon contain evidences of his exact learning. He received the degree of LL.D. from Cambridge in 1883, from Edinburgh in 1890, and the degree of D.C.L. from Oxford also in 1890. In 1905 Göttingen renewed *honoris causa* the degree of Ph.D. which he had received at that University in 1855. At home he received honorary degrees from Amherst, Chicago, Columbia, Yale, and Harvard. He enjoyed the rare distinction of being twice president of the American Philological Association (1871 and 1884); he was vice-president of the Egypt Exploration Fund; for many years he was closely identified with the work of the Archæological Institute of America; and he held the office of president of the American Academy of Arts and Sciences in 1903. He was an honorary member of the Hellenic Society of London, of the Philological Society of Cambridge, England, of the Hellenic Society of Constantinople, of the Archæological Society and Academy of Science at Athens, and was a foreign member of the Imperial German Archæological Institute.

Professor Goodwin was not a blind worshipper of the classical literature of the ancients; he saw in it, not an agent for the discipline of the intellect of all youth, but an instrument, imperative for the understanding of the development of European letters, and salutary for those who would deepen their appreciation of English literature. In him the intellectual spirit of scientific research in the field of grammar did not blunt the literary and artistic sense, which, as has well been said, is partly also moral. The old-time humanities translated themselves in him into the spirit of just and refined living. He did not confine his sympathies to the ancient world that was his by the association of daily work; but he realized, in the words of Renan, that "progress will eternally consist in developing what Greece conceived"; and from Greece he gathered, what many of the noblest and best have gathered thence, a large part of that wisdom of life which is more precious and more enduring than mere learning.

HERBERT WEIR SMYTH.

MINUTES.

MINUTES.

Stated Meeting January 3, 1913.

WILLIAM W. KEEN, M.D., LL.D., President, in the Chair.

Thanks were received from the Naturwissenschaftliche Verein für Steiermark for the Society's friendly good wishes upon the occasion of, and for the sending of a delegate to, its Semi-Centenary.

Professor Herbert Weir Smyth presented an obituary notice of Professor William Watson Goodwin.

The following papers were read:

"The Historic Value of Old Law Books," by Hampton L. Carson, Esq.

"Place and Personal Names of the Gosiute Indians of Utah," by Ralph V. Chamberlin (introduced by the Secretaries).

The Judges of the Annual Election of Officers and Councillors held on this day between the hours of two and five in the afternoon, reported that the following named members were elected, according to the Laws, Regulations and Ordinances of the Society, to be the officers for the ensuing year:

President,

William W. Keen.

Vice-Presidents,

William B. Scott,
Albert A. Michelson,
Edward C. Pickering.

Secretaries,

I. Minis Hays,
Arthur W. Goodspeed,
Amos P. Brown,

Harry F. Keller.

Curators,

Charles L. Doolittle,
William P. Wilson,
Leslie W. Miller.

Treasurer,

Henry La Barre Jayne.

Councillors

(To serve for three years),

Charlemagne Tower,
William Morris Davis,
George Ellery Hale,
R. A. F. Penrose, Jr.

(To fill an unexpired term),

Samuel W. Pennypacker.

Stated Meeting February 7, 1913.

WILLIAM W. KEEN, M.D., LL.D., President, in the Chair.

The death was announced of George Augustus Koenig, A.M., Ph.D., at Philadelphia, on January 14, 1913, æt. 69.

Dr. Paul Heyl (introduced by Professor Harry F. Keller) read a paper on "Platinum in North Carolina," which was discussed by Professor Keller.

Stated Meeting March 7, 1913.

WILLIAM W. KEEN, M.D., LL.D., President, in the Chair.

An invitation was received from the President and Executive Committee of the Twelfth International Geological Congress, inviting the Society to be represented at the Congress to be held in Canada in the month of August.

Dr. R. M. Pearce (introduced by Dr. W. W. Keen) read a paper on "The Gradual Development of the Idea of Cellular Structure throughout the Animal and Vegetable Kingdom," which was discussed by Dr. Coplin, Dr. Tyson, Professor Kraemer, Dr. Hawke, Dr. Donaldson and Dr. Harshberger.

The following Address was adopted:

To His Excellency
Woodrow Wilson,

Sir: The American Philosophical Society extends its cordial congratulations to you, as one of its fellow members, upon your accession to the Presidency of the United States. You carry into public life the ideals of the scholar and you will show in the new world, as has been proved so often in the old, that scientific training in the best and broadest sense of the term, is a help to the practical statesman. Your studies in history and political science will illuminate your task of giving to the Nation a wise and strong government.

It was Montesquieu, the good genius of the makers of our National Constitution, who said that for a safe voyage of the Ship of State the spirit of the laws should serve as compass and history should be the chart. This Society confidently believes that you have at your command this compass and this chart; that with your firm hand at the helm the Ship of State will safely ride the seas, and that, like those of your distinguished predecessors in the Presidency, who were its members, you will help to make the future history of the Nation worthy of its past.

Seven times since the founding of the Republic the American Philosophical Society has had cause for congratulation in the selection of one of its members as President of the United States. Washington, Adams, Jefferson, Madison, the second Adams, Buchanan and Grant were all honored names upon its Roll before the popular vote inscribed them in the list of American Presidents. To you, the eighth in turn of its members to enter upon this high office, this Society extends its warmest greeting.

Given under the Seal and in the name of The American Philosophical Society held at Philadelphia for Promoting Useful Knowledge, this seventh day of March, 1913.

Stated Meeting April 4, 1913.

William W. Keen, M.D., LL.D., President, in the Chair.

The following letter was received from President Wilson in response to the address presented to him by the Society on March 19:

THE WHITE HOUSE,
WASHINGTON, March 19, 1913.

My dear Dr. Keen: May I not express to you, and through you to the members of the American Philosophical Society, my deep and sincere appreciation of the cordial message brought me from the Society by you and your associates this afternoon? Nothing has gratified me more. I do not know of any Association whose confidence I would rather enjoy. It has been a matter of peculiar pride to me to be associated with the American Philosophical Society, and that that distinguished body should feel honored by my elevation to the Presidency is a source of genuine satisfaction to me. I can only say in reply to their gracious Address that I shall hope and strive at all times to deserve their respect and confidence.

Cordially and sincerely yours,
WOODROW WILSON.

The decease of the following members was announced:

Professor Angelo de Gubernatis, at Rome, on February 27, 1913; æt. 73.

John Shaw Billings, M.D., LL.D., Dc.L., at New York, on March 10, 1913; æt. 74.

Edward Pepper, LL.D., at Algiers, on March 23, 1913; æt. 66.

James McCrea, at Ardmore, Pa., on March 28, 1913; æt. 65.

The following papers were read:

"Illuminants Present and Future," by Herbert E. Ives, Ph.D. (introduced by Dr. W. W. Keen), which was discussed by Professor Ferree.

"The Fluting and Pitting of Granites in the Tropics," by John C. Branner, Ph.D., LL.D.

"The True Atomic Weight of Bromine," by Gustavus Hinrichs (Introduced by Professor Keller).

General Meeting April 17, 18, and 19, 1913.

Thursday, April 17. Opening Session—2 o'clock.

WILLIAM W. KEEN, M.D., LL.D., President, in the Chair.

Professor J. C. Kapteyn, elected to membership in 1907, signed the roll and was admitted into the Society.

An invitation was received from the Missouri Botanical Society

to be represented at the opening of its new hall on May 1 and 2, and Professor Francis E. Nipher was appointed to represent the Society on the occasion.

The following papers were read:

"The Biographies of Suetonius," by John C. Rolfe, Ph.D., Professor of the Latin Language and Literature, University of Pennsylvania.

"The Etymology of the Word 'Ill,'" by Hermann Collitz, Ph.D., Professor of Germanic Philology, Johns Hopkins University.

"The Treaty Obligations of the United States relating to the Panama Canal," by Charlemagne Tower, A.B., LL.D., Philadelphia.

"A Counsel of Perfection. A Plan for a State University and for an Automatic Collection and Distribution of a State Tax for Higher Education," by Joseph G. Rosengarten, A.M., LL.D., Philadelphia. Discussed by Dr. Cyrus Adler.

"Reprisals, Contraband and Piracy under Queen Elizabeth," by Edward P. Cheyney, A.M., LL.D., Professor of European History, University of Pennsylvania. Discussed by Mr. Harrison S. Morris and Mr. Rosengarten.

"Some Commercial Transactions in Babylonia During the Period of Greek Supremacy," by Albert T. Clay, A.M., Ph.D., Laffan Professor of Assyriology and Babylonian Literature, Yale University.

"The Historical Value of the Patriarchal Narratives," by George A. Barton, A.M., Ph.D., Professor of Semitic Languages, Bryn Mawr College.

"The Succession of Human Types in the Glacial and Interglacial Epochs of the European Pleistocene," by Henry Fairfield Osborn, D.Sc., LL.D., Research Professor of Paleontology, Columbia University, New York.

"The Flora of Bermuda" (illustrated), by Stewardson Brown, Conservator, Botanical Section, Academy of Natural Sciences of Philadelphia (introduced by Professor Henry Kraemer).

"A New Type of Sewage Disposal Tank," by William Pitt

Mason, M.D., LL.D., Professor of Chemistry, Rensselaer Polytechnic Institute, Troy, N. Y.

"Determination of Uranium and Vanadium in Carnotite Ores of Colorado," by Andrew A. Blair, Philadelphia.

Friday, April 18. Morning Session—9.35 o'clock.

WILLIAM W. KEEN, M.D., LL.D., President, in the Chair.

The following papers were read:

"The Uses and Needs of Selachology (The Study of Sharks and Rays)," by Burt G. Wilder, M.D., Emeritus Professor of Neurology and Vertebrate Zoology, Cornell University.

"Interpretations of Brain Weight" (illustrated), by Henry H. Donaldson, Ph.D., D.Sc., Professor of Neurology at The Wistar Institute of Anatomy and Biology, Philadelphia.

"The Correlation of Structural Development and Function in the Growth of the Vertebrate Nervous System" (illustrated), by George E. Coghill, Ph.D., Professor of Zoölogy, Denison University, Granville, Ohio (introduced by Dr. H. H. Donaldson).

"The Correlation of Structure and Function in the Development of the Nervous System" (illustrated), by Stewart Paton, M.D., Lecturer in Biology, Princeton University (introduced by Dr. A. C. Abbott).

"The Relation Between the Physical State of the Brain Cells and Brain Function (experimental and clinical)," by George W. Crile, M.D., Ph.D., Professor of Clinical Surgery, Western Reserve University, Cleveland. Discussed by Professor Conklin, Dr. Paton, Dr. Minot and Professor Nipher.

"Life of Cells Outside the Organism" (illustrated), by Ross G. Harrison, M.D., Ph.D., Professor of Comparative Anatomy, Yale University (introduced by Dr. A. C. Abbott). Discussed by Dr. Crile and Dr. Donaldson.

"Heredity and Selection," by William E. Castle, Ph.D., Professor of Zoölogy, Harvard University.

"The Nature of Sex and the Method of Its Determination"

(illustrated), by Clarence E. McClung, A.M., Ph.D., Professor of Zoölogy, University of Pennsylvania (introduced by Dr. George A. Piersol). Discussed by Dr. Minot.

"Fever: Its Nature and Significance," by Victor C. Vaughan, M.D., LL.D., Professor of Hygiene and Physiological Chemistry, University of Michigan. Discussed by Dr. Wilder.

"The Control of Typhoid Fever by Vaccination," by Mazÿck P. Ravenel, M.D., Professor of Bacteriology, University of Wisconsin.

Afternoon Session—2 o'clock.

WILLIAM B. SCOTT, Ph.D., Sc.D., LL.D., Vice-President, in the Chair.

The following papers were read:

"Gautemala and the Highest Native American Civilization," by Ellsworth Huntington, M.A., Ph.D., Assistant Professor of Geography, Yale University (introduced by Mr. Henry G. Bryant). Discussed by Professor Scott and Mr. Joseph Willcox.

"Further Considerations on the Origin of the Himalaya Mountains and the Plateau of Tibet," By T. J. J. See, A.M., Ph.D., U. S. Naval Observatory, Mare Island, Cal.

"Dana's Contribution to Darwin's Theory of Coral Reefs," by William Morris Davis, Sc.D., Ph.D., Sturgis-Hooper Professor of Geology, Emeritus, Harvard University. Discussed by Professor Scott.

"The Formation of Coal Beds," by John J. Stevenson, A.M., LL.D., Emeritus Professor of Geology, University of the City of New York.

"Cambrian Fossils from British Columbia" (illustrated), by Charles D. Walcott, Ph.D., Sc.D., LL.D., Secretary of the Smithsonian Institution.

"The Alleghenian Divide and Its Influence Upon Fresh Water Faunas," by Arnold E. Ortmann, Ph.D., Sc.D., Curator of Invertebrate Zoölogy, Carnegie Museum, Pittsburgh. Dis-

cussed by Mr. Joseph Willcox and Professor W. M. Davis.

"Neutralization and Elimination of Toxic Substances," by Oswald Schreiner, Ph.D., Chief of Division of Soil Fertility Investigations, Department of Agriculture, Washington. Discussed by Dr. Harshberger and Professor Nipher.

"Progressive Evolution Among Hybrids of Oenothera" (illustrated), by Bradley M. Davis, A.M., Ph.D., Assistant Professor of Botany, University of Pennsylvania (introduced by Professor John M. Macfarlane).

"Climatic Areas of the United States as Related to Plant Growth" (illustrated), by Burton E. Livingston, Ph.D., Professor of Plant Physiology, Johns Hopkins University (introduced by Professor John W. Harshberger). Discussed by Dr. Harshberger, Professor Scott, and Professor Nipher.

"The Day of the Last Judgment," by Paul Haupt, Ph.D., LL.D., Professor of Semitic Languages, Johns Hopkins University.

"On the Character and Adventures of Mūladora," by Maurice Bloomfield, Ph.D., LL.D., Professor of Sanskrit and Comparative Philology, Johns Hopkins University.

Evening Session.

George Grant MacCurdy, A.M., Ph.D., Assistant Professor of Archæology, Yale University, gave an illustrated lecture on "The Antiquity of Man in the Light of Recent Discoveries."

Saturday, April 19.

Executive Session—9.30 o'clock.

WILLIAM W. KEEN, M.D., LL.D., President, in the Chair.

Pending nominations for membership were read and the Society proceeded to an election.

Secretary Keller and Professor Rolfe served as tellers and reported that the following nominees had been elected to membership:

Residents of the United States

George Francis Atkinson, Ph.D., Ithaca, N. Y.
Charles Edwin Bennett, A.B., Litt.D., Ithaca, N. Y.
John Henry Comstock, B.S., Ithaca, N. Y.
Reginald Aldworth Daly, Boston, Mass.
Luther Pfahler Eisenhart, Princeton, N. J.
George W. Goethals, Culebra, Canal Zone.
William C. Gorgas, M.D., Sc.D., LL.D., Ancon, Canal Zone.
Ross G. Harrison, A.B., Ph.D., M.D., New Haven, Conn.
George Augustus Hulett, Princeton, N. J.
Clarence E. McClung, A.M., Ph.D., Swarthmore, Pa.
John Dyneley Prince, Ph.D., Sterlington, N. Y.
Samuel Rea, Sc.D., Bryn Mawr, Pa.
Henry Norris Russell, Ph.D., Princeton, N. J.
Charles Schuchert, New Haven, Conn.
Witmer Stone, A.M., Philadelphia.

Foreign Residents.

Sir Arthur John Evans, D.Litt., LL.D., F.R.S., Oxford, Eng.
Sir Joseph Larmor, D.Sc., LL.D., F.R.S., Cambridge, Eng.
Arthur Schuster, Sc.D., Ph.D., F.R.S., Manchester, Eng.

Morning Session—10 o'clock.

EDWARD C. PICKERING, D.Sc., LL.D., F.R.S., Vice-President, in the Chair.

The following papers were read:

"The Potassium, Phosphorus, Nitrogen Cycles," by Charles E. Munroe, Ph.D., LL.D., F.C.S., Professor of Chemistry, George Washington University, Washington.

"An Ammonia System of Acids, Bases and Salts," by Edward C. Franklin, Chief of Division of Chemistry, U. S. Public Health and Marine Hospital Service. Discussed by Dr. H. C. Jones and Professor H. F. Keller.

"Some Unsolved Problems in Radio-activity" (illustrated), by

William Duane, Ph.D., late of the Curie Radium Laboratory, University of Paris (introduced by Professor Arthur W. Goodspeed). Discussed by Dr. H. C. Jones, Mr. E. C. Franklin and Mr. Joseph Willcox.

"Some Diffraction Phenomena; Superposed Fringes," by Charles F. Brush, Ph.D., LL.D., Cleveland, O.

"Matter in its Electrically Explosive State," by Francis E. Nipher, A.M., LL.D., Professor of Physics, Washington University, St. Louis.

"New Investigations of Resonance Spectra," by Robert Williams Wood, A.B., LL.D., Professor of Experimental Physics, Johns Hopkins University. Discussed by Professor Schuster.

"Application of Recent Studies on the Origin of the Earth's Magnetic Field to the Possible Magnetic Fields of Rotating Bodies in General" (illustrated), by Louis A. Bauer, Ph.D., Director of the Department of Terrestrial Magnetism of the Carnegie Institution, Washington.

"The Determination of Visual Stellar Magnitudes by Photography," by Edward C. Pickering, D.Sc., LL.D., F.R.S., Director of the Harvard College Observatory, Cambridge.

"Some Problems in Connection with the Milky Way, as Shown by Photographs Made with Portrait Lenses," by Edward E. Barnard, Sc.D., LL.D., Astronomer of the Yerkes Observatory, Williams Bay, Wis.

"The Spectroscopic Detection of the Rotation Period of Uranus," by Percival Lowell, LL.D., and V. M. Slipher, Ph.D., of the Lowell Observatory, Flagstaff, Arizona.

"On the Spectrum of the Nebula in the Pleiades," by V. M. Slipher, Ph.D., of the Lowell Observatory, Flagstaff, Arizona.

"Eclipsing Variable Stars," by Henry Norris Russell, Ph.D., Professor of Astronomy and Director of the Observatory, Princeton University (introduced by Professor William F. Magie).

"Progress of New Lunar Tables," by Ernest W. Brown, M.A., Sc.D., F.R.S., Professor of Mathematics, Yale University.

Dr. John Mason Clarke, elected to membership in 1911, Dr. E. C.

Franklin, elected in 1912, and Professor Henry Norris Russell, a newly elected member, subscribed the laws and were admitted into the Society.

Afternoon Session—2 o'clock.

EDWARD C. PICKERING, D.Sc., LL.D., F.R.S., Vice-President, in the Chair.

A portrait of William W. Keen, M.D., LL.D., President of the Society, was presented by Joseph G. Rosengarten, A.M., LL.D., on behalf of the subscribers.

Mr. Chairman and Members:

On behalf of the subscribers, I have the honor and privilege of presenting to the Society, the portrait of our President, Dr. William W. Keen, by Robert Vonnoh.

Among the one hundred and twenty-nine subscribers,—a list will be handed to the Secretaries for preservation among its records, will be found the names of many representatives of institutions of learning, many men noted in science and letters, who thus testify their grateful sense of Dr. Keen's great services to the Philosophical Society, both as member and as President.

His portrait is that of the seventeenth President, thus adding one more to the long series that adorn this hall, beginning with the first president, Hopkinson, followed by Franklin, Jefferson, Rittenhouse, Wistar, the two Pattersons, father and son, Tilghman, Chapman, the two Baches, Kane, Wood, Fraley, the second Wistar, Edgar F. Smith, and now Keen.

This portrait represents Dr. Keen seated in Franklin's chair, and in the cap and gown of the University of St. Andrews, for both Franklin and Keen were the recipients of its Doctor's degree.

Of Dr. Keen's distinguished career, it is enough to say that a graduate of Brown University in 1859, he is also a Trustee and Fellow, as well as the recipient from that University, and from Toronto and Yale and Greifswald and Upsala and St. Andrews, of their highest academic honors.

His services as a surgeon in the Civil War covered nearly the whole period of that struggle.

His work as a teacher began in the Philadelphia School of Anatomy in 1866, and ended only when he resigned in 1907, after long and brilliant service in Jefferson Medical College.

His contributions to medical and general literature have won for him a place among our authors.

Retired from the active practice of his profession, with the grateful acknowledgments and regrets of his colleagues, his students and his patients, he has given time and thought to his duties as President of the American Philosophical Society.

In acknowledgment of his great service in that office, his fellow members, and some not members of the Society, join in presenting his portrait to the Philosophical Society that it may take its place on the walls of this Hall, with the long list of the portraits of his predecessors.

By his services to the world and to the Society, he has won the affection and esteem typified in the portrait now presented to the Society.

The portrait was accepted on behalf of the Society by Vice-President Pickering, who said:

To render a scientific society successful, it is necessary that at least two or three of its members should devote a large part of their time and energy to its administration. Even then it is not easy to secure an annual meeting which many regard as the most interesting of its kind in the country. While it is eminently fitting that the oldest scientific society of America should maintain this position, those of us who see something of the management each year, realize how largely this is due to the successful administration of our seventeenth President, supported as he is by the unwearied efforts of other officers of the Society. This painting will always serve as a reminder of the able and tactful services of Dr. Keen.

The annual meetings are remarkable not only for the high grade of the papers presented but, what is unusual, for their interest to specialists in other departments of human knowledge. For this

reason, many of us come hundreds of miles to meet our fellow members here.

By the authority and in the name of the American Philosophical Society held at Philadelphia for Promoting Useful Knowledge, I accept this gift with grateful acknowledgments and the hope that it may be many years before we are obliged to elect the eighteenth President of the Society.

Dr. Arthur Schuster, Dr. Ross G. Harrison and Professor Clarence E. McClung, newly elected members, subscribed the laws and were admitted into the Society.

The following papers were read:

"Symposium on Wireless Telegraphy, Radiated and Received Energy," by Lewis W. Austin, Ph.D., Head of U. S. Naval Radio-Telegraph Laboratory, Bureau of Standards, Washington (introduced by Professor William F. Magie).

"Resonance in Radiotelegraphic Receiving Stations," by George W. Pierce, A.M., Ph.D., Assistant Professor of Physics, Harvard University (introduced by Professor Arthur W. Goodspeed).

"New Form of Resonance Circuits," by Michael I. Pupin, Ph.D., Sc.D., Professor of Electro-Mechanics, Columbia University, N. Y.

"The International Radiotelegraphic Conference of London and its Work," by Arthur Gordon Webster, Ph.D., LL.D., Professor of Physics and Director of the Physical Laboratory, Clark University, Worcester.

Stated Meeting May 2, 1913.

WILLIAM W. KEEN, M.D., LL.D., President, in the Chair.

Dr. Witmer Stone, a newly elected member, subscribed the laws and was admitted into the Society.

Acknowledgment of election to membership was received from

George Francis Atkinson, Ph.D., Ithaca, N. Y.

Charles Edwin Bennett, A.B., Litt.D., Ithaca, N. Y.

John Henry Comstock, B.S., Ithaca, N. Y.

Reginald Aldworth Daly, Boston, Mass.
Luther Pfahler Eisenhart, Princeton, N. J.
George Augustus Hulett, Princeton, N. J.
John Dyneley Prince, Ph.D., Sterlington, N. Y.
Samuel Rea, Sc.D., Bryn Mawr, Pa.
Witmer Stone, A.M., Philadelphia.

Obituary notices of Horace Howard Furness, Litt.D., LL.D., by Professor F. E. Schelling, His Excellency M. Jusserand, Dr. LeBaron Briggs, Dr. Morris Jastrow, Jr., and Mr. Owen Wister were read.

The decease was announced of Lester F. Ward, A.M., LL.D., at Washington, April 18, 1913; æt. 72.

The application of the cinematograph to studies in biology was demonstrated by Professor A. W. Goodspeed, Dr. W. M. L. Coplin and Dr. A. P. Brubaker, and was discussed by Dr. Keen.

Stated meeting October 3, 1913.

WILLIAM W. KEEN, M.D., LL.D., President, in the Chair.

Letters accepting membership were received from:

Sir Joseph Larmor
Prof. Arthur Schuster
Prof. Charles Schuchert
Col. George W. Goethals
Dr. William C. Gorgas
Prof. Reginald A. Daly
Sir Arthur John Evans.

Invitations were received:

From the Director of the Imperial Botanical Garden of St. Petersburg to the Bi-Centennial Jubilee of the founding of the Garden, on June 21–25, 1913.

From the Directors and Faculty of Ursinus College to the inauguration of George Leslie Omwake, as President, on October 7th.

From the President, Trustees and Faculty of Princeton University to the dedication of the Graduate College, on October 22d.

The decease of the following members was announced:

William Hallock, Ph.D., at Providence, R. I., on May 20, 1913, æt. 56.

Rt. Hon. John Lubbock, Lord Avebury, D.C.L., LL.D., F.R.S., on May 28, 1913, æt. 79.

Philip Lutley Sclater, M.A., D.Sc., at Odiham Priory, Winchfield, Hants, Eng., on June 27, 1913, æt. 83.

Charles H. Cramp, A.B., Sc.D., at Philadelphia, on June 6, 1913, æt. 85.

Horace Jayne, M.D., Ph.D., at Wallingford, Pennsylvania, on July 8, 1913, æt. 54.

William Tatham, at Paris, on September 10, 1913, æt. 63.

William Armstrong Ingham, C. E., at Philadelphia, on September 23, 1913, æt. 87.

The following papers were read:

"Factors in the Exchange Value of Meteorites," by Warren M. Foote. (Introduced by Prof. Harry F. Keller.)

"The Nomenclature of Minerals," by Austin F. Rogers. (Introduced by Prof. John C. Branner.)

"The Marine Tertiary Stratigraphy of the North Pacific Coast of America," by Ralph C. Arnold and Harold Hannibal. (Introduced by Prof. John C. Branner.)

"Geology of the Region about Natal, Rio Grande do Norte, Brazil," by Olaf Pitt Jenkins. (Introduced by Prof. John C. Branner.)

Stated Meeting November 7, 1913.

WILLIAM W. KEEN, M.D., LL.D., President, in the Chair.

The decease was announced of

Sir William Henry Preece, K.C.B., at London, on November 6, 1913, in his eightieth year.

Alfred Russell Wallace, O.M., LL.D., D.C.L., at Broadstone, Wimborne, Eng., on November 7, 1913, in his ninety-first year.

Prof. John M. Macfarlane read a paper "On the Phylogeny of Plants in Relation to their Environment."

Stated Meeting December 5, 1913.

WILLIAM W. KEEN, M.D., LL.D., President, in the Chair.

The decease was announced of Sir Robert Stawell Ball, Kt., M.A., LL.D., F.R.S., at Cambridge, England, on November 26, 1913, æt. 73.

Dr. Simon Flexner read a paper on "Epidemiology of Disease with Special Reference to Infantile Paralysis."

The President read his "Annual Address."

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